COOPERATION

CANADA- NOVA SCOTIA COOPERATION AGREEMENT ON MINERAL DEVELOPMENT

ENTENTE DE COOPÉRATION CANADA-NOUVELLE-ÉCOSSE SUR L'EXPLOITATION MINÉRALE

Nova Scotia

Cana

93-01547/

A STUDY ON THE CONTROL OF GROUNDWATER HAZARD AT GAYS RIVER MINE

VOLUME I

PROJECT OVERVIEW

CONTRACT SERIAL NO. 23440-0-9235-01-SQ
CONTRACTOR: WESTMINER CANADA LIMITED
VOL. I of VII

TITLE: **A STUDY ON THE CONTROL OF GROUNDWATER HAZARD AT GAYS RIVER MINE**

FINAL REPORT

BY

Westminer Canada Limited
Seabright Operations

This work was supported under the Canada-Nova Scotia Cooperation Agreement on Mineral Development and was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada.

DSS FILE NO: 33SQ.23440-0-9235

DSS CONTRACT SERIAL NO: 23440-0-9235/01-SQ

CANMET SCIENTIFIC AUTHORITY: Dr. T. R. C. ASTON, P. Eng.

DATE: MARCH 27, 1992

80 pp

MICROMEDIA

ABSTRACT

This report outlines the study undertaken to assess and investigate sources of groundwater inflow to the Gays River Mine. The study consisted of five individual investigations: a hydrochemical assessment, a review of drainhole well screens and an underground pressure point measurement program, preparation of a computer model, an airphoto interpretation study of sinkhole features, and a major piezometer installation and overburden soil investigation program. The study concluded that the sources of the underground water flows are a combination of recharge from the Gays River, precipitation over a drawdown "cone", and some additional, possibly regional, inflow. The pathways for the flow are considered to be mainly through overburden sands and permeable, karsted gypsum on the gypsum-overburden and gypsum-trench contacts. The study concluded that control of the mine water inflow was achievable and outlined a number of recommendations for consideration.

RÉSUMÉ ANALYTIQUE

Le présent rapport trace les grandes lignes de l'étude entreprise pour évaluer et examiner les sources de l'eau souterraine présente dans la mine de Gays River. L'étude a été effectuée en cinq volets : une évaluation hydrochimique, un examen des drains du puits de drainage et un programme de mesure de la pression interstitielle, l'élaboration d'un modèle informatique, l'interprétation par photo aérienne des caractéristiques des dolines, l'installation de piézomètres et un vaste programme d'étude des sols de couverture. Selon les conclusions de l'étude, l'eau souterraine provient de plusieurs sources, soit par alimentation de la rivière Gays, par des précipitations dans un cône de rabattement, et par un afflux sans doute régional. Les eaux de ruissellement empruntent les trajets sablonneux de la couverture et des zones de contact perméables de gypse à karst sur la couverture de gypse et le long des lapiés de gypse. D'après les conclusions de l'étude, le contrôle de l'écoulement de l'eau dans la mine est possible, et des recommandations ont été présentées aux fins de considération.

EXECUTIVE SUMMARY

Mining operations at the Gays River Mine have been adversely impacted by groundwater difficulties during two production periods. Consistent mine production was impeded by periods of both excessive inflow rates and high, rising groundwater levels resulting from restricted borehole drainage to the mine. This study was undertaken with the intent of identifying the mine water sources, assessing their relative importance, and outlining methods to solve or control the water problems.

The study was supported under the Canada-Nova Scotia Cooperation Agreement on Mineral Development. It was carried out in three phases, the first of which was preparation of a historical data overview report. The second phase was a review and assessment of the mine area hydrology and field program scoping by a 'panel of experts'. The third phase was a series of field investigation programs. Four initial field investigation programs were conducted; a hydrochemical analysis of mine and regional water flows, an assessment of mine drainhole well screens and a mine pressure point investigation, preparation of a numerical computer model, and an airphoto study and interpretation of sinkhole features. Following initial results from these investigations, an extensive piezometer and overburden soil investigation program was carried out.

The Phase I report, entitled "Gays River Mine Dewatering and Water Inflow Prevention" was prepared by Mr. G. M. Meyer of Western Mining Corporation Limited. This report provided a summary of pertinent data gathered to the end of 1990 and summarized the author's assessment of the hydrology. The primary source of the mine water inflow was considered to be ultimately from precipitation after transmission through the overburden and evaporite bedrock aquifers. Additional recharge from surface sources was postulated, particularly from the river floodplain when in flood stage. Other sources of mine inflow water, including aquifer storage and regional underflow, were also noted. The major recommendations made were to establish additional underground drainholes, take steps towards a reduction in solids discharge in the mine drainage water, review the possibility of utilizing existing boreholes from surface for dewatering and to carry out a geophysics/piezometer installation program.

An experienced group of hydrologists was selected to attend the 'panel of experts' meetings held on May 13 and 14, 1991. Prior to the meetings, each participant was provided with Mr. Meyer's report. The first day consisted of a general overview of the mine geology and hydrology, followed by an underground tour and a tour of the local area. During the second day's meeting, each participant gave their thoughts and impressions of the hydrological environment and participated in arriving at a general consensus regarding possible sources of water recharge and direction for the field program of the study.

It was the general conclusion of the expert panel that the mine inflow water was recharged from surface precipitation and possible river recharge through the overburden in the local area, and then through karsted gypsum along the gypsum-trench contact. It was agreed that the field investigation program should be started with a hydrochemical analysis of all water sources and an investigation into the development, location and recharge possibilities of sinkholes. There was some question with regard to the success of plastic drainhole screens in the proposed screened drainholes and some members felt that simple computer modelling of the local and mine area would be appropriate. All of the participants agreed that a piezometer installation program, coupled with an investigation of the overburden soils, would be required to assess and define the sources of recharge to the mine. All of this recommended work was carried out.

The hydrochemical analysis study was completed by Jacques Whitford Environment Limited. The historical water sampling results were reviewed and assessed. Water was sampled from 33 underground points, 14 surface water sites and 8 deep monitoring wells. As well, the Gays River was profiled using a "Hydrolab Water Quality Monitoring System" in 12 sinkhole locations, which indicated up to five 'active' sinkholes. Selected samples were subjected to environmental isotope analysis. The hydrochemical investigation concluded that the primary source of mine water is from storage in cavernous gypsum, which is augmented and diluted by water from other sources, including water from the Gays River. The study found that four mine water chemical types were present: i) weak calcium-sulfate, ii) strong calcium-sulfate, iii) "diluted" calcium-sulfate and iv) surficial water. Analysis of the water flowing from the major drainage areas indicated that the major flows are a combination of gypsum formation water and shallow meteoric waters. The environmental isotope analysis indicated that the mine water is predominantly of meteoric origin.

An assessment of the drainhole screens was carried out by Golder Associates Limited. At the time of the assessment, the screen selection and installation had been changed to a 50 slot, stainless steel screen and this was determined to be appropriate. A series of pressure monitoring points was also commissioned in order to determine aquifer conductivity and groundwater levels. However, the results were affected by flows from adjacent holes and the uncertainty of the hole surface area that contributed to the flows.

The development of sinkholes in the mine area was considered to warrant concern. An airphoto interpretation and study was therefore conducted by J. D. Mollard and Associates Limited to identify sinkhole locations and possible sinkhole affected recharge areas. In excess of 100 sinkholes were identified, dating back less than 13,000 years. Based on information available at the time, the airphoto study could not assess the impact of the sinkholes on the mine hydrology. The airphoto study recommended that a field investigation of boreholes, piezometers and possible use of geophysical methods be carried out.

A simple numerical computer model of the Gays River Mine hydrological regime was prepared by Fracflow Consultants Limited. The model was successfully calibrated to reflect a steady state mine inflow of about 4,000 USgpm and identified a number of water pathways. However, the model did not predict significant increases in mine water inflow as a result of rain or river flooding, and some of the pathway predictions were not considered plausible. The Gays River hydrological environment is very complex, and it is considered that a more realistic computer model would require significant effort to prepare and calibrate.

The major field work undertaken during this study was the piezometer installation program and overburden investigation completed by Golder Associates Limited. Thirty-five boreholes were drilled at 28 locations and 49 piezometers installed to determine and monitor groundwater levels. The holes were generally logged in detail and soil samples were taken for identification and testing. Geophysical logging was completed in some of the pre-existing monitoring wells and some of the new piezometers. The study identified six Pleistocene soil units and two possibly Cretaceous soil units. The overburden geology is complex, however the Pleistocene soil units can be correlated over the site. The study demonstrated that the three overburden sand units are aquifers.

The Golder Associates study determined that the sources of mine water recharge are:

i) precipitation over the drawdown cone, (estimated at 1,055-2,110 USgpm)
ii) recharge from the river, (estimated at a minimum of 1,000-1,800 USgpm)

These estimated flows are based on a steady state mine inflow of 4,000 USgpm. The major flow pathway is considered to be interconnected karst zones in the gypsum adjacent to the trench and underlying the overburden, and other flow pathways are presented and discussed. The major recommendations made in the report are to continue development of screened underground drainage holes, evaluate modifications to the Gays River in order to reduce infiltration, and to evaluate the potential for surface dewatering wells adjacent to the river in the area determined to be recharging the overburden from the river.

In general, all of the work carried out during the summer and fall of 1991 demonstrated that control of the mine area groundwater can be maintained through the use of screened underground drainage boreholes. Additional drainhole drilling is recommended and an ongoing drainhole installation program may be required throughout the life of the mine. The recharge component originating from the Gays River may be reduced by carrying out modifications to the river as well as installation of overburden dewatering wells in the overburden aquifers.

CONDENSÉ

Les travaux d'exploitation de la mine de Gays River ont été contrecarrés par la présence d'eau souterraine pendant deux périodes de production. En effet, des périodes d'afflux excessif et de hauts niveaux de la nappe aquifère dus à un drainage restreint des trous de mine ont nui à la production soutenue. La présente étude visait à trouver les sources de l'eau d'exhaure, à évaluer leur importance relative et à déterminer les méthodes de solution ou de contrôle des problèmes causés par l'eau.

L'étude a été entreprise grâce à une aide en vertu de l'Entente de coopération en matière de développement minier Canada-Nouvelle-Écosse. Elle s'est déroulée en trois étapes, dont la première a visé la rédaction d'un rapport de synthèse des données existantes. La seconde étape à englobé l'évaluation d'ensemble de l'hydrologie de la zone minière et la détermination par un groupe d'experts de la portée du programme sur le terrain. Une série de programmes d'examens sur le terrain constituait la troisième phase de l'étude. Quatre programmes d'examens sur le terrain ont été initialement menés : une analyse hydrochimique des écoulements d'eau dans la mine et dans la région, une évaluation des drains du puits de drainage et la mesure de la pression interstitielle, la préparation d'un modèle informatique numérique, ainsi que l'examen de photos aériennes et l'interprétation des configurations des dolines karstiques. À la suite des premiers résultats de ces enquêtes, un programme exhaustif d'examen piézométrique ainsi que du sol de couverture a été mené à bien.

M. G.M. Meyer, de Western Mining Corporation Limited, a rédigé le rapport de la Phase I intitulé «Gays River Mine Dewatering and Water Inflow Prevention» (Assèchement de la mine de Gays River et prévention de l'entrée d'eau). Le rapport contient un résumé de toutes les données pertinentes recueillies jusqu'à la fin de 1990, ainsi qu'une synthèse de l'évaluation hydrologique par l'auteur. Selon lui, les précipitations avaient traversé les sols de couverture et les aquifères de la roche de fond poreuses. Il admet qu'il y a eu alimentation de surface provenant des inondations de la plaine. Il fait remarquer d'autres sources de l'afflux, notamment l'accumulation aquifère et la résurgence régionale. L'auteur recommande en particulier l'établissement de puits de drainage supplémentaires, des mesures de réduction de rejets solides dans l'eau d'exhaure de la mine, l'examen de la possibilité d'utiliser les trous de sonde en place

pour l'assèchement et pour la réalisation d'un programme d'installation de piézométrie/de géophysique.

Des hydrologistes expérimentés ont été choisis pour assister aux réunions du «groupe d'experts» qui ont eu lieu les 13 et 14 mai 1991. Avant ces réunions, chaque participant avait reçu le rapport de M. Meyer. La première journée a été consacrée à l'étude d'ensemble de la géologie et de l'hydrologie de la mine, suivie une visite souterraine et d'une tournée de la région. Pendant la deuxième journée, chaque participant a exprimé ses impressions relatives à l'environnement hydrologique et a contribué au consensus à propos des sources possibles de la présence d'eau, ainsi qu'au sujet de l'orientation du programme sur le terrain.

Le groupe d'experts est arrivé à la conclusion que l'eau d'afflux dans la mine provient des précipitations en surface au travers des terrains de couverture puis des gypses karstiques, le long des discontinuités des diaclases de gypse. Il a été convenu d'entamer, dans le cadre du programme de recherche sur le terrain, une analyse hydrochimique de toutes les sources d'eau et de déterminer les possibilités de développement, du lieu et de l'alimentation des dolines. La question du succès des tamis plastiques dans les trous de drainage prévus a été débattue, et certains membres ont pensé qu'une simple modélisation informatisée de la mine et de la région serait appropriée. Tous les participants se sont mis d'accord sur la nécessité d'installer un piézomètre et de mener une étude corrélative des sols de couverture, afin d'évaluer et de définir les sources d'alimentation de l'eau présente dans la mine. Tous ces travaux recommandés ont été effectués.

L'analyse hydrochimique est l'oeuvre de Jacques Whitford Environment Limited. Les résultats des études d'échantillons d'eau antérieurs ont été examinés et évalués. Des échantillons d'eau ont été prélevés de 33 points souterrains, de 14 points en surface et de 8 puits profonds de contrôle. La rivière a aussi été profilée à l'aide d'un analyseur de contrôle automatique de la qualité des eaux Hydrolab, dans 12 points de karst à dolines, ce qui a permis de déterminer jusqu'à cinq dolines «actives». Des échantillons ont fait l'objet d'une analyse isotopique. L'examen hydrochimique a permis de conclure que la première source de l'eau présente dans la mine venait de l'accumulation d'eau dans les grottes de gypse, additionnée d'eau interstitielle d'autres sources, y compris l'eau de la rivière Gays. Selon les conclusions de l'étude, on a trouvé

quatre types de produits chimiques dans l'eau : i) sulfate de calcium en faible concentration, ii) sulfate de calcium en forte concentration, iii) sulfate de calcium «dilué» et iv) eau superficielle. L'analyse de l'eau s'écoulant des principales zones de drainage signifie que les principaux flux sont une combinaison d'eau en formation de gypse et de l'eau atmosphérique. L'analyse isotopique montre que l'eau de la mine est surtout d'origine atmosphérique.

Golder Associates Limited a procédé à l'évaluation des entailles et mailles des drains. Au moment de l'évaluation, on avait changé la sélection et installé des tamis en acier inoxydable de 50 mailles qui devaient suffire. On avait décidé d'installer une série de points de surveillance de la pression interstitielle afin de déterminer la conductivité aquifère et les niveaux de la nappe phréatique. Les résultats ont toutefois été modifiés par l'écoulement de trous adjacents et l'incertitude de la surface des trous a contribué aux écoulements d'eau.

Le développement de karst à dolines dans la zone de la mine est devenu préoccupant. L'interprétation de photographies aériennes et une étude ont donc été effectuées par J.D. Mollard and Associates Limited afin de délimiter des dolines et les zones possibles d'alimentation. On a trouvé plus de 100 dolines, remontant à moins de 13 000 ans. Selon les renseignements disponibles au moment de l'étude, l'examen des photographies aériennes n'a pas permis d'évaluer les effets des dolines sur l'hydrologie de la mine. L'examen photographique n'a fait que confirmer la nécessité de faire une étude, sur le terrain des trous de sonde, et de recourir à des piézomètres ainsi qu'à des méthodes géophysiques.

Fracflow Consultants Limited a établi un simple modèle numérique du régime hydrologique de la mine de Gays River. Le modèle a été calibré avec succès et a montré que la venue d'eau constante était d'environ 4 000 gpmUS et a déterminé les trajets d'écoulement de l'eau. Le modèle n'a toutefois pas prédit des augmentations importantes de l'afflux de l'eau à la suite de pluies et de crues de la rivière, et certaines prévisions de trajets de l'eau n'ont pas paru très plausibles. Le bassin hydrologique de la rivière est très complexe, et l'on pense qu'un modèle informatisé plus réaliste exigerait d'énormes efforts pour arriver à l'élaborer et à le calibrer.

Les principaux travaux sur le terrain pendant l'étude, qui ont porté sur l'installation de piézomètres et sur l'évaluation des terrains de couverture, ont été effectués par la société Golder Associates Limited. Trente-cinq trous de sonde ont été forés en 28 endroits, et 49 piézomètres ont été installés afin de déterminer les niveaux de l'eau de fond. Des diagraphies précises ont été faites et des échantillons de sol ont été prélevés aux fins d'identification et d'essais. Des diagraphies géophysiques ont été prises dans d'anciens puits de contrôle ainsi que grâce à de nouveaux piézomètres. L'étude a permis de déceler six carottes du Pléistocène et peut-être deux du Crétacé. La géologie de la couverture est très complexe, mais les sols du Pléistocène peuvent être corrélés au site. L'étude a démontré que trois zones sablonneuses de couverture sont aquifères.

L'étude effectuée par le cabinet Golder Associates a déterminé que les sources d'alimentation en eau présente dans la mine sont les suivantes :

i) précipitations sur le cône de rabattement (évaluées à quelque 1 055-2 110 gpmUS)
ii) alimentation de la rivière (évaluée à un minimum de 1 000 à 1 800 gpmUS)

Ces estimations des flux sont fondées sur une arrivée d'eau constante dans la mine de 4 000 gpmUS. Le principal trajet suivi par l'eau, sans être relié aux zones de gypse karstique adjacentes à la fissure et sous-jacentes à la couverture, et d'autres trajets de flux sont présentés et traités par la suite. Les principales recommandations du rapport visent à faire des drains souterrains, à évaluer les modifications à la rivière afin de réduire l'infiltration, et à évaluer la possibilité d'installer des puits d'assèchement en surface, adjacents à la rivière, dans la zone d'alimentation de la couverture.

En règle générale, tous les travaux effectués en été et en automne 1991 ont prouvé qu'il est possible de contrôler l'eau dans la zone de la mine en installant des drains souterrains. Il est recommandé de forer d'autres drains et il faut prévoir un programme d'installation de drains pendant toute la durée de vie de la mine. L'eau provenant de la rivière Gays peut être réduite en apportant des modifications au lit de la rivière et en installant des puits d'assèchement de la couverture dans les aquifères de celle-ci.

LIST OF REPORT VOLUMES

Volume I . . . . . PROJECT OVERVIEW

Volume II . . . . . GAYS RIVER MINE DEWATERING AND WATER INFLOW PREVENTION
(Phase I Report)
By: G. M. Meyer,
Western Mining Corporation Limited.

Volume III . . . . . OVERBURDEN DRILLING INVESTIGATION AND HYDROGEOLOGICAL ASSESSMENT
GAYS RIVER MINE
MILFORD STATION, NOVA SCOTIA
By: Golder Associates Limited

Volume IV . . . . . UNDERGROUND DEWATERING AND STABILITY CONSIDERATIONS
GAYS RIVER, NOVA SCOTIA
By: Golder Associates Limited

Volume V . . . . . HYDROCHEMISTRY ASSESSMENT OF MINE WATER
GAYS RIVER LEAD-ZINC MINE
By: Jacques Whitford Environment Limited

Volume VI . . . . . OFFICE AIRPHOTO MAPPING AND CORRELATION OF SINKHOLES WITH AVAILABLE MAPS AND REPORTS:
GEOLOGIC AND HYDROGEOLOGIC DATA SYNTHESIS
WESTMINER MINE SITE AND SURROUNDING AREA
By: J. D. Mollard. Ph. D., P. Eng., P. Geol.
J. D. Mollard and Associates Limited

Volume VII . . . . . NUMERICAL INVESTIGATION OF GROUNDWATER INFLOW,
GAYS RIVER MINE, N. S.

By: R. MacLeod, G. G. Bursey, J. E. Gale
Fracflow Consultants Inc.

VOLUME I - PROJECT OVERVIEW

TABLE OF CONTENTS

ABSTRACT i
RÉSUMÉ ANALYTIQUE i
EXECUTIVE SUMMARY ii
CONDENSÉ vi
LIST OF REPORT VOLUMES x

1.0 INTRODUCTION 1

2.0 STUDY FORMAT 6
2.1 Phase I 6
2.2 Phase II 7
2.3 Phase III 10

3.0 DISCUSSION 12
3.1 Piezometer Installation and Overburden Investigation 13
3.2 Drainhole Screen Assessment and Installation of Underground Pressure Monitoring Points 16
3.3 Hydrochemistry Assessment 19
3.4 Airphoto Interpretation Study 22
3.5 Computer Modelling 25

4.0 SUMMARY AND CONCLUSIONS 27

5.0 RECOMMENDATIONS 28

6.0 REFERENCES 31

APPENDIX A Minutes of Phase II Panel of Experts Meeting
APPENDIX B 1991 Daily Deep Well Groundwater Monitoring Data
APPENDIX C 1991 Weekly Deep Well Groundwater Monitoring Data
APPENDIX D 1991 Mine Discharge Water Chemistry

1.0 INTRODUCTION

The Gays River Mine is an underground lead-zinc operation located in central Nova Scotia, approximately 50 km northeast of Halifax. The property was explored during the early 1970's and subsequently developed and put into production by a subsidiary of Imperial Oil Limited in 1979. Production difficulties and groundwater problems plagued the operation and mining was suspended in 1981. During the following year, efforts were made to evaluate alternative mining approaches and conduct an extensive hydrological investigation program, however, in August 1982 the decision was made to close the mine and the mine workings were allowed to flood.

The Gays River property was acquired by Seabright Resources Inc. in 1985 with the intent of utilizing the mill for processing both lead-zinc ores and gold ores from exploration properties being worked by Seabright. Shortly after the acquisition of the property, lead and zinc prices fell to low levels and plans to reopen the Gays River Mine were suspended. In 1988, Seabright Resources was acquired by Westminer Canada Limited and, as a result of rising metal prices, interest in the mine was renewed.

Dewatering of the mine workings was started in April 1989 and test mining carried out beginning in August 1989. The mine workings were completely pumped out by January 1990. Westminer made the decision to put the mine into production and commercial production was attained in March 1990. The approach taken by Westminer in operating the mine was different than that taken by Imperial Oil. Much of the highest grade mineralization had not been mined by Imperial Oil as it was adjacent to a consolidated soil ("trench"). Westminer's mining approach was to drain the groundwater and extract the high grade material adjacent to the trench.

The mineralization at Gays River is contained in reef dolomites and limestones of the Mississippian age Windsor Group. These carbonates rest unconformably on Goldenville Formation quartzites and slates of Ordovician age. The carbonate reef was formed during Lower Mississippian time on a quartzite ridge separating the Musquodoboit Basin to the south and the Shubenacadie Basin to the northeast.

Subsequent to the development of the carbonate reef, thick formations of evaporites were deposited in the adjacent basins. These formations were later exposed

and eroded, resulting in significant karst development, particularly along the evaporite/carbonate reef interface. A sinuous karst erosion feature developed along the evaporite/carbonate contact, and was infilled with Cretaceous to Recent age sediments. Both the erosion feature and the infill sediments are locally referred to as the "trench".

The mine workings drained an average inflow of about 4,000 USgpm. The major portion of the mine water inflow, estimated at 2,500-3,000 USgpm, drained from the 118 area boreholes. Efforts to manage the water inflow were inconsistent. On occasion, difficulties arose due to inflows in excess of local pumping capacity, but the major groundwater problem was the inability to maintain drainage of sufficient water to maintain low groundwater levels. The majority of the ore zones are adjacent to the trench (consolidated soil) and stability of the exposed trench was contingent on maintaining it in a dry condition and ensuring that no hydrostatic pressure developed adjacent to or within the trench.

The amount of water inflow to the mine varied seasonally and with precipitation events. Following heavy rainfalls, mine drainage rates increased as much as 1,500 USgpm to rates in the order of 5,500 USgpm. Flooding of the river floodplain also occurred during these periods and may be directly related to increases in the mine drainage rate. Blockages of the underground drainholes, particularly during wet weather, occasionally resulted in quickly rebounding groundwater levels to elevations above exposed trench in stoping areas. The stopes were temporarily shut down during these rebounds in groundwater levels, seriously impacting mine production. The mine water inflow also carried with it significant quantities of suspended solids, in sizes ranging from clay to 5 cm pebbles. The solids caused excessive pump wear, filling of sumps and contributed to drainhole blockage.

Through both periods of mine operation, development of sinkholes on surface occurred occasionally. The mechanisms for sinkhole development are postulated to be:

i) dissolution of soluble gypsum, creating cavities, and causing subsidence of overlying overburden.

ii) transport of soil infill out of evaporite cavities and caverns, creating voids, and causing subsidence of overlying overburden.

iii) transport of soil particles from the lower levels of the overburden, removing support for overlying soils and creating subsidence to surface.

iv) depressurization of cavern and cavity infill as a result of dropping water levels, resulting in settlement of overlying sediments and eventual subsidence to surface.

v) exposure of saturated trench or overburden within the mine workings, and subsequent flow of the soils, resulting in removal of support for overlying sediments and subsidence to surface.

The first four of these postulated mechanisms are the result of groundwater flow, which would have been accelerated by drainage to the mine workings. It should also be noted that sinkhole development occurs naturally in the area and it has been a relatively active sinkhole area during the post-Glacial period.

Various studies and investigations have been carried out on the Gays River Mine hydrology and much experience was gained by Imperial Oil during it's period of mine operation. Since 1989, groundwater levels, pumping rates, and mine discharge water chemistry have been monitored and recorded by Westminer and a number of small hydrology oriented studies conducted. However, by the end of 1990, the understanding of groundwater sources, mechanisms and pathways was not complete. The mine operation continued to be adversely affected by the inability to control the groundwater and was unable to maintain consistently low groundwater levels. Further lowering of groundwater levels was also required in order to allow for extraction of deeper ore zones.

In early 1991, work on this study was initiated in order to address the mine water inflow difficulties. The study was supported under the Canada-Nova Scotia Cooperation Agreement on Mineral Development. As well, efforts were made to develop reliable underground drainholes which would not conduct excessive levels of suspended solids. A horizontal drainhole drilling contractor, Mobile Aardvark Drill Inc. was retained to drill and install screened drainholes.

The drainholes were designed to be collared in carbonate or quartzite, and drilled through the trench infill and a cavernous contact zone into solid evaporite. The sections of the hole through the cavernous contact zone, the trench and any sections that produced water would be screened with well screen. Previous open drainholes had been susceptible to draining high levels of suspended solids and also to plugging off. The installation of screens was intended to enable consistent flows to be maintained without excessive suspended solids. It was hoped that a natural "gravel pack" would eventually develop around the well screens, in a manner similar to a domestic water supply well, and this would filter out almost all suspended solids.

A serious groundwater rebound began on April 28, 1991, when flows in both main 118 drainholes became restricted. From a usual flow of about 2,500 USgpm, flows from the holes dropped off to less than 1,000 USgpm. Later that night, efforts were made to clear the blockages and much of the flow was restored, however, groundwater levels had risen about 11 m and did not begin dropping. On May 2 and 3, there was 78 mm of rainfall, which further contributed to high groundwater levels. The groundwater levels continued to slowly rise until May 8, when a water inflow of about 1,000 USgpm occurred in the CA 846/437 Stope. (846 Stope). A waste rock plug was immediately placed in the stope access crosscut, but later that evening an inflow of soil and gypsum boulders occurred that washed the waste rock down the 848 Ramp. Subsequently, water flow from the 846 Stope dropped to less than 100 USgpm and groundwater levels resumed rising. The ramp and stope were not recovered. Following this event, mining operations were suspended in all but the highest elevation stopes. Efforts to lower the groundwater levels during May were not successful.

Attempts to clear the main 118 drainholes continued and were successful in June. Groundwater levels were dramatically lowered. Occasionally through the summer, further blockage of the main 118 drainholes occurred and was cleared. By the end of August, flow from the screened drainholes installed in the 118 area replaced flow from the (former) main 118 drainholes.

On May 30, 1991, as a result of the continuing groundwater problems, extremely low production and financial losses, Westminer made the decision to temporarily suspend production until both control of the groundwater and economically viable mining could be achieved. Work was conducted throughout the summer towards these objectives and

control of the groundwater was considered to have been achievable. However, given the relatively low metal prices, Westminer management made the decision to make the property available for sale in the fall of 1991. No acceptable offers for the property were received, and in February 1992, the decision was made to place the property on a "care and maintenance basis". The mine workings were allowed to flood, however, all of the assets and equipment were left on site to permit the rapid resumption of mining, at a time of higher metal prices and more attractive mining economics.

This study has served to greatly increase the understanding of the hydrological environment of the Gays River Mine area. It will be of value to the operator when mining operations are resumed.

2.0 STUDY FORMAT

The current study was carried out in three phases as described in the following sections:

2.1 Phase I

A vast quantity of groundwater monitoring and water chemistry data had been gathered by Westminer during 1989 and 1990. As Phase I of this study, Mr. Gary Meyer, a hydrologist with Western Mining Corporation Limited (parent company of Westminer Canada Limited), reviewed all of the existing information and data. He compiled an overview report including all of the pertinent data and outlined his assessment of the mine area hydrology.

The Phase I report, entitled "Gays River Mine Dewatering and Water Inflow Prevention" is included as Volume II of this report. The report was sent to all of the participants of the 'panel of experts' meeting for their background information and familiarization prior to the meeting.

The report summarized Mr. Meyer's assessment of the hydrology. Two principal aquifers were identified, the overburden aquifer comprised of sands and gravels, and the bedrock aquifer comprised of interconnected karstic gypsum cavities and fractured carbonates and quartzites. The aquifers are considered to be hydraulically connected in some areas. The main source of water recharge to the mine is considered to be precipitation, which is conducted through both the overburden and bedrock aquifers to the mine. The report discusses the 'extra' mine water inflow of 500-1,500 USgpm above normal levels that occurs after heavy rainfall and river flooding. Other sources of mine water inflow, from sinkholes such as Taylor's pond, aquifer storage and regional inflow, are noted. A substantial review of the mine water chemistry data was undertaken and described in the report. The water chemistry reflects high levels of Ca and SO_4 as would be expected in water in contact with relatively soluble gypsum. The high HCO_3 content of the mine discharge water was interpreted to indicate the presence of surface water recharge.

The following major recommendations were made:

- establish additional underground drainholes.
- monitor suspended solids levels in the drainage water.
- take steps towards a reduction in solids discharge with the mine drainage water.
- review the possibility of utilizing existing surface boreholes for dewatering.
- carry out a geophysics investigation and a piezometer installation program.
- modify the groundwater monitoring program.
- conduct additional, more site-specific water sampling and analysis.

Following the anticipated success of a piezometer program to identify major sites of water inflow to the bedrock aquifer, possible methods to prevent such inflow are proposed for consideration, including grouting or dewatering using shallow well pumps.

2.2 Phase II

A 'think tank' approach to postulating the mine water recharge sources, mechanisms and possible controls was employed as Phase II of this study. A number of qualified experts in the field of hydrology were selected to take part in a 'panel of experts'. Some of the participants had carried out previous work on the property. Each of the participants was asked to review the Phase I report and prepare for the two-to-three day 'panel of experts' meetings.

The participants took part in an underground tour and a tour of the local area on the first day, May 13, 1991. The status of the mine at the time, regional and mine geology and the hydrological environment were outlined and discussed during the day.

The following hydrologists participated in the Phase II tours and meeting.

Mr. David MacFarlane	Jacques, Whitford & Associates Limited
Mr. Robert Blair	Golder Associates Limited
Dr. Trevor Carter	Golder Associates Limited
Mr. James Fraser	Porter Dillon Limited
Mr. Frederick Baechler	Nolan Davis & Associates Limited
Dr. John Gale	Fracflow Consultants Inc.
Mr. Russ Slayback	Leggette, Brashears and Graham, Inc.

The tour and meetings were attended by Dr. Tim Aston (meeting chairman) of CANMET and Joe Campbell, Roger Levesque and Tom Lamb of Westminer Canada Limited. Dr. Don Jones of the Nova Scotia Department of Mines and Energy attended the tour and minesite discussions on May 13.

During the meetings held on the second day, May 14, the mine area hydrology was extensively reviewed and discussed. Each of the hydrologists outlined their views and opinions. The panel concluded that the source of the recharge for the mine inflow water is precipitation over the general area and possible seepage from the river. The panel felt that the most likely path of the mine water is through the overburden deposits into the karsted evaporite bedrock and along the trench-evaporite contact zone. An extensive program of piezometer installation and monitoring was proposed in order to confirm this conclusion and identify areas where effective control of the water might be possible. However, the panel felt that some additional work should be initiated prior to the piezometer program. The panel concluded that a hydrochemical analysis of the mine and mine area water sources should be carried out initially. As well, some of the experts proposed that a simple numerical computer model of the area hydrology be prepared.

The panel also strongly expressed the opinion that the drainhole well screen selection should be reviewed with regard to screen slot size and screen construction material. All members of the panel felt that stainless steel screens should be utilized, rather than the PVC screens planned at the time.

Subsequent to the conclusion of the Phase II meetings, the following work was scoped out as Phase III of the study:

1) A hydrochemical survey of all mine and local area water flows and a review of the existing water chemistry data. Compilation, review and documentation of all data, information determined and conclusions reached. Make recommendations for any future hydrochemical monitoring.

2) Preparation of a simple computer model of the Gays River Mine area hydrological regime.

3) Assessment of the underground drainhole screen installation. As well, complete a review of the application and feasibility of underground pressure measurements. Provide input with regard to flow monitoring requirements from underground drainholes.

4) An airphoto interpretation study of the area to identify sinkholes and sinkhole areas, particularly with regard to likely recharge areas.

5) Carry out a program to install and monitor a series of overburden and near-surface piezometers in order to determine the near surface flow regime. The overburden lithology would be defined during the program based on drill information. The piezometer program would be started after assessment of the initial information determined from the initial Phase III studies.

The minutes of the Phase II meetings were prepared by Dr. Tim Aston and are included as Appendix A of this Volume.

2.3 Phase III

The third phase of the study generally proceeded as planned at the conclusion of Phase II.

Jacques Whitford Environment Limited were selected to carry out the hydrochemical survey and assessment. Their report on the work, entitled "Hydrochemistry Assessment of Mine Water, Gays River Lead-Zinc Mine" is included as Volume V of this report.

A simple computer model of the Gays River hydrological environment was prepared by Fracflow Consultants Inc. The model and results are outlined in their report entitled "Numerical Investigation of Groundwater Inflow, Gays River Mine, N. S." which is included in this report as Volume VII.

Dr. Trevor Carter of Golder Associates Limited completed the assessment of the drainhole well screens and looked after the installation of 11 pressure gauges on existing flowing underground drillholes. Flow tests were carried out on the pressure monitoring points as practicable. A report on this work, entitled "Underground Dewatering and Stability Considerations", was prepared and is included as Volume IV of this report. The report also includes general observations, recommendations and memos prepared by Dr. Carter during the study period.

An airphoto interpretation study was completed by Dr. J. D. Mollard of J. D. Mollard and Associates Limited. As part of the study a substantial amount of reference information was assembled and compiled in the report. In excess of 100 sinkholes were noted and some correlation identified between lithological features and sinkhole development. Dr. Mollard's report, entitled "Office Airphoto Mapping and Correlation of Sinkholes with Available Maps and Reports: Geologic and Hydrogeologic Data Synthesis, Westminer Mine Site and Surrounding Area" is included in this report as Volume VI.

The piezometer installation and overburden investigation program was started early in July 1991. Golder Associates Limited was selected to carry out the program.

The report on this work is entitled "Overburden Drilling Investigation and Hydrogeological Assessment, Gays River Mine", and is included in this report as Volume III.

3.0 DISCUSSION

Concurrent with the hydrology work underway on this study, additional hydrological investigations were conducted by Westminer and a hydrology consulting group. (Adrian Brown Consultants Inc.). Some investigation into the flow of the Gays River was conducted and Martec Limited[1] carried out stream flow gauging during June 1991. The stream flow gauging showed that flow in the Gays River decreased dramatically over a section of the river adjacent to the mine workings. At the time of the stream flow gauging, the river flow was at a very low level as a result of dry weather, and discharge from the mine tailings pond constituted much of the river flow in the mine area. Flow from the tailings pond to the Gays River was estimated at 4,000 USgpm, and discharges to the river upstream of the mine workings. Martec determined that the flow at a point in the river just upstream of the mine workings was 6,715 USgpm (June 19, 1991) and at a point downstream in the river the flow had dropped to 4,666 USgpm (June 18, 1991). Earlier stream flow measurements[2], carried out in November 1989, had shown that the river flow increased over this area at that time of year. The June 1991 measurements supported the hypothesis of groundwater recharge to the mine from the river.

In order to further assess the effect of the river on the mine groundwater inflow, arrangements were made to divert the discharge of the tailings pond from the point in tne Gays River upstream of the mine workings to a point southwest of the mine and into the South Branch Gays River. As the river flow was very low due to the dry weather, the tailings pond discharge made up the largest part of the river flow. Diversion of this discharge from the Gays River would minimize flow in the river. The effect of the river in the hydrological environment would be further assessed by evaluating the response of mine water inflow, deep groundwater monitoring wells, shallow piezometers, and the river flow itself at the very low river flows.

The first effect of the diversion of the tailings pond discharge to the South Branch Gays River was that a section of the main branch of the Gays River, downstream of the mine workings, dried up over a period of six days. This demonstrated that there was seepage from the river into the river bottom. As that section of the river flowed over the mine "drawdown cone", the seepage would have made its way to the mine workings. Other effects of the tailings pond discharge diversion and riverbed drying up were a

significant drop in total mine water discharge and a drop in the groundwater level in deep monitoring well ETW-2. A full report and discussion of this diversion is given in Volume III, Golder Associates' Overburden Drilling Investigation and Hydrogeological Assessment. The diversion and its effect on the hydrological regime demonstrated that the recharge from the Gays River to the mine was 1,000 to 1,800 USgpm during low summer flow conditions. This was a major advance in the understanding of the Gays River Mine hydrology, as all previous investigations to determine or evaluate a hydraulic connection between the Gays River and the mine had not shown any hydraulic connection during normal river flow conditions.

3.1 Piezometer Installation and Overburden Investigation

The major fieldwork undertaken as part of this study was the installation of a network of piezometers and an investigation of the overburden geology and hydrology. A network of piezometers was required in order to measure groundwater levels and determine flow patterns within the mine area overburden. As well, installation of the piezometers afforded the opportunity to conduct overburden exploration and evaluation. Golder Associates Limited were selected to carry out this investigation. Their report on the work, entitled "Overburden Drilling Investigation and Hydrogeological Assessment, Gays River Mine" is included as Volume III of this report. The report includes pertinent data, relevant figures and presents a detailed assessment of the mine area hydrology.

A total of 49 piezometers were installed in 35 boreholes in 28 locations. The investigation identified a total of nine overburden soil units with stratigraphy as follows:

Recent	Peat, Clay, Sand Alluvium and Colluvium
Pleistocene	Upper Lacustrine Clay
	Upper Sand
	Red Till
	Lower Lacustrine Clay
	Lower Sand
	Lower Till
Cretaceous	Clay
	Sand

The Pleistocene soil stratigraphy can be correlated over the mine area. Two additional soil types were noted and discussed. These are cavern infill that was encountered within caverns in gypsum bedrock, and the trench soil adjacent to the carbonate which was sampled in 841 West Stope. Each of the units is described in the report.

The sand units form aquifers and the clay and till units are aquitards. Soil testing was carried out on samples of the overburden units and the results are discussed in the report and documented in Appendix C of Volume III. Hydraulic conductivities of the soils were evaluated using falling head or rising head piezometer response tests conducted in most of the piezometers. As well, the hydraulic conductivities of the sandy soils were determined using the Hazen method, based on the laboratory soil test work. The hydraulic conductivity of the tills and clays was in the order of 1×10^{-6} cm/sec or less. The hydraulic conductivities of the sands, using the Hazen method, ranged between 4×10^{-1} and 9×10^{-6} cm/sec, but generally were in the order of 5×10^{-3} cm/sec, which is considered to be relatively permeable.

Monitoring of the groundwater levels in the piezometers and pre-existing deep monitoring wells demonstrated that drainage to the mine has developed an extensive drawdown cone, roughly estimated to be 10 km^2 in area. Approximately 2.5 km of the Gays River flows within the estimated limits of the drawdown cone. As discussed

previously, the results of the tailings pond diversion trial demonstrated that the Gays River contributes 1,000 to 1,800 USgpm recharge to the mine workings. This aspect is discussed in greater detail in Volume III.

The investigation concluded that inflow to the mine workings consisted of two main components:

i) precipitation over the drawdown cone contributed between 1,055 and 2,110 USgpm.

ii) seepage from the Gays River contributed 1,000 to 1,800 USgpm.

In addition, the investigation identified a "balance" component of 90 - 1945 USgpm which likely represents uncertainties in the area of the drawdown cone and the degree of inflow from the river. These flow rates are estimates based on a steady state mine inflow of 4,000 USgpm. During high mine water inflow periods, the river recharge component was estimated to range from 1,500 to 3,300 USgpm of a total mine inflow of 6,000 USgpm.

Conduits for the mine water inflow were determined to be the overburden sand units and the permeable, karsted zones at the overburden-evaporite and trench-evaporite contacts.

An area of groundwater level fluctuations in response to rainfall and river flow changes was identified northwest of the 118 area. Five of the Golder Associates series piezometers are located in this area and have shown response to variations in river flow and rainfall events. There is some evidence presented to suggest that a major groundwater pathway exists in this area.

The report presents a number of conclusions, many of which have been discussed in the preceding section.

The study made the following recommendations:

- Continue development of underground screened drainholes.
- Consider engineering modifications to the river to limit infiltration. (improved channelization, channel lining, levee construction, upstream flow regulation dam)
- Consider installation of interception wells at strategic areas adjacent to the river to reduce overall recharge to the mine.
- Conduct further investigation of potential groundwater transmission along the trench, including additional monitoring wells.
- Consider transducer monitoring of key surface monitoring wells, selected underground monitoring points and the discharge weir to supply a central engineering station with continuous data.
- Review the current groundwater level monitoring network and install additional monitoring wells if required.
- Assess water quality relationships between the river and mine water when the river water chemistry is not dominated by the mine discharge water.
- Locate and fill river channel and floodplain sinkholes to reduce infiltration.

3.2 Drainhole Screen Assessment and Installation of Underground Pressure Monitoring Points

Most of the participants of the Phase II meetings were concerned about the success of the PVC well screens intended for use in the screened underground drainholes. Golder Associates Limited were selected to assess the screened drainhole program and provide advice on screen selection and the drainhole program. As well, they were asked to look after the installation of a network of underground pressure monitoring points. This work was carried out and a report entitled "Underground Dewatering and Stability Considerations, Gays River, Nova Scotia" was prepared. The Golder report also includes selected memos prepared by Golder Associates over the study period and documents pertinent data. The report is included as Volume IV of this report.

The initial drainholes screened with the 1.5" diameter 10 Slot PVC well screen were not successful and the screens plugged off soon after installation. Drainhole screen installation was revised to permit the use of 2.625" outside diameter (3" telescopic), 50 Slot, stainless steel screen. This screen worked much better. Upon his review, Dr. Trevor Carter of Golder Associates considered the screen and installation appropriate. Possible future difficulties were noted and suggestions were made for screening out fines, in the event that the fines discharge became excessive.

Eleven underground pressure monitoring points were established at previously flowing boreholes. Flow tests were conducted on most of the boreholes and simplified transmissivity and approximate permeability calculations completed. The calculations showed that transmissivities are generally in the order of 10^{-6} to 10^{-4} m^2/sec and hydraulic conductivities are in the order of 10^{-4} to 10^{-2} cm/sec. As noted in the report, these calculated conductivities are based on assumptions regarding the surface area of the permeable zone contributing to the flow and are considered to be guideline values.

The report includes summary tables listing all of the screened drainholes drilled during 1991. The pressure point monitoring records to October 17 are also presented. Water levels, based on static pressure at the pressure monitoring points, were calculated and graphed. It should be noted that the static pressure recorded for some of the monitoring points was affected by water flow in adjacent drainholes, resulting in apparently low pressure measurements, which are not completely reflective of groundwater levels.

After a review of the conductivity and pressure data, a recommendation was made that the optimum locations for screened drainholes would be in areas with high existing static pressure and high hydraulic conductivity.

A number of conclusions and recommendations were made in the report. The following outlines the major points noted:

- It was concluded that dewatering control can be achieved with the use of underground screened drainholes.
- A recommendation was made that consideration be given to the installation of permanent underground pressure transducer monitoring

points in critical areas, with possible output to surface.

- The requirement for quantification of the fines discharge with the drainage water was stressed and possible control methods proposed. The report stresses that undue volumes of fines washed out of the trench and karst voids will result in sinkhole subsidence and underground instability, with possible ever-increasing water inflows. Control and monitoring of the fines content of the drainage water is considered imperative.
- The possible long term solutioning of drainholes within gypsum was noted, and recommendations made to monitor gypsum drainholes for solutioning and make preparations for remediation.
- The report also recommended that the annulus between the drainhole collar pipes and drainpipes of the screened drainholes be sealed to prevent flow from bypassing the well screens.
- The installation of piezometer tips to measure pore pressure in the trench was presented for consideration.
- Consideration should be given to the establishment of surface dewatering wells near the ends of the mine (along strike) to reduce water flow to the underground drainage system.
- Consideration should also be given to the installation of surface dewatering wells into zones of permeable gypsum beneath the overburden to intercept river infiltration and provide subdrainage of overburden water.

Concerns were expressed with regard to maintaining control of the trench wall during stoping and maintaining the "stability" of installed drainholes due to fines migration.

A specific comment was made in regard to the effect of the Gays River in flood and the following options outlined for consideration to prevent flooding of the river floodplain:

i) provision of an upstream control structure.
ii) channelization of the river.
iii) river diversion.

The report stressed that inundation of the river floodplain should be prevented.

3.3 Hydrochemistry Assessment

A report describing the hydrochemical survey and assessment carried out by Jacques Whitford Environment Limited is included in this report as Volume V. The assessment included a review of the previous water quality sampling results and wide sampling and analysis of both surface and underground water flows.

The review of the historical water quality data showed that both the mine and the surface waters were dominated by $CaSO_4$. This is a result of gypsum in the overburden and bedrock. A correlation between arsenic, possibly associated with gold ore processing, in the tailings and mine water was noted which would suggest the tailings pond and/or river as a source of mine water recharge. However, there remains some doubt as to the validity of the arsenic analysis results, due to the end of detectable levels of arsenic in the mine discharge water after the change of laboratories in July 1990.

After the review of the historical water quality data, the assessment came to the following conclusions:

i) A good hydraulic connection between the surface and the mine is suggested as changes over time in the mine discharge water chemistry are a result of changes in the relative proportion of surface water entering the mine.

ii) Trace element data, particularly arsenic and zinc, also indicates a connection with river water.

iii) The concentration of magnesium could be useful in determining the proportion of mine water originating in the carbonate.

iv) Serious problems exist with the quality of the water chemistry data prior to July 1990, which has made the validity of the data questionable.

The hydrochemical assessment included sampling and analysis of 33 underground water flows, collection of water samples at 14 surface water locations, profiling of 12 previously identified sinkholes in the Gays River, and sampling of eight deep groundwater monitoring wells. As well, two bedrock samples were taken for isotopic analysis. Where practicable, insitu measurement of sensitive parameters was carried out using a Hydrolab Surveyor 3 Water Quality Logging System. Most water samples were analyzed for major ions and 14 of the samples were analyzed for trace metals. Samples from selected locations were subjected to environmental isotope analysis.

The following outlines the conclusions reached in the hydrochemical sampling and analysis study:

1) The primary source of mine water is derived from storage in the cavernous gypsum aquifer northwest of the mine.

2) This calcium-sulfate water is mixed or diluted with groundwater of lower total dissolved solids from other sources.

3) The 1989 to 1991 mine water discharge chemistry data indicates a significant input of shallow groundwater and surface water during the wet portions of the year.

4) The spatial underground chemistry and hydrolab results indicate four mine water chemical types:
    i) weak calcium-sulfate
    ii) strong calcium-sulfate
    iii) "diluted" calcium-sulfate
    iv) surficial water

5) The chemical, isotopic and flow monitoring information indicates that most of the mine water is associated with the trench-gypsum contact.

6) A significant degree of mixing between gypsum formation waters and shallow meteoric water at the major drainholes at 118 and 808 is indicated by the data.

7) The environmental isotope analysis indicates that the mine waters are dominated by water of meteoric origin.

8) The primary recharge to the mine workings appears to originate from a northwest direction and hydrochemical data suggests that the primary source of the low total dissolved solids component of the mine water is from sinkhole affected areas and permeable sands located along the Gays River to the northwest of the 118 Area.

9) The portal area in the vicinity of the sand pit is being recharged from the overlying surficial deposits through fractured bedrock.

10) The bulk mine discharge water and water from the major drainholes are undersaturated with respect to gypsum, indicative of actively dissolving gypsum. The Sulfur-34 isotopes indicate that the dissolved sulfate is derived from gypsum dissolution.

11) The best indicators of mine water mixing with water from a surface source are the presence of tritium, elevated dissolved oxygen, elevated groundwater temperature, high redox potentials, and chemical dilution effects.

12) Using hydrochemical profiling, three sinkholes in the Gays River have been identified as being active, and an additional two sinkholes may be active.

13) Chemistry and isotope data show that the river water chemistry below the tailings pond discharge point is dominated by the mine discharge water during dry portions of the year.

14) Given the assumption that the mine is in equilibrium with the gypsum aquifer most of the time, the main source of additional inflow during wet periods of the year appears to be from the Gays River, possibly through associated surficial aquifers and sinkhole conduits.

15) The hydrochemical assessment supports the likelihood of a significant river water component to the mine water inflow with a seasonal variation in input.

The hydrochemical assessment also presented a number of recommendations in regard to a water monitoring strategy, outlining sampling locations, frequencies, and parameters.

Further investigation of the active river bottom sinkholes using mini-piezometers, seepage meters, and possibly, tracer dyes was recommended. As well some additional detailed hydrochemical analysis work was recommended.

3.4 Airphoto Interpretation Study

The development of sinkholes in the local area has been assessed as a possible conduit for groundwater recharge. The area has been a somewhat active sinkhole area, both prior to development of the mine and subsequent to dewatering by the mine operations. Taylor's pond, northeast of the mine workings, has been identified as a large sinkhole which predates mining activity. A tracer dye test[3] conducted in 1990, demonstrated that a direct hydraulic connection exists between the Taylor's pond sinkhole and the 101 area mine workings. However, this sinkhole only recharges the mine inflow significantly after very heavy rainfall events and is not considered a major source of mine water recharge. The airphoto interpretation study was carried out to locate additional sinkhole development and assess it as groundwater conduits and/or sources. The possibility of controlling recharge through sinkholes by plugging them or redirection of surface water away from them, and thereby reducing inflow to the mine, warranted investigation.

As well, airphoto interpretation can be useful in hydrological assessments to outline possible sources and aquifers. J. D. Mollard and Associates was selected to carry out an airphoto interpretation study of the Gays River Mine area and identify existing sinkholes, especially those that were suspected of conducting water to the mine workings.

A report on the airphoto interpretation work was prepared by Dr. J. D. Mollard and is included as Volume VI of this report.

The airphoto study consisted initially of the compilation of existing geological and hydrogeological maps and extracts of relevant reports. After a general base of information had been assembled, the author was able to identify over 100 sinkholes. These sinkhole locations are shown on the figures included in the report (Volume VI). He noted that most of the sinkholes are related to lithological features; geological contacts, joints and faults. A number of airphotos were interpreted, including photos taken in 1954, 1959, 1979 and 1990. It was interesting to note that sinkholes had developed in the area that is now the tailings pond. Numerous small sinkholes were noted in the floodplain of the Gays River, which could conceivably drain to the bedrock and subsequently to the mine when inundated during river flooding.

The following summarizes the conclusions and recommendations presented in the report:

1) An extensive groundwater control exploration program, likely involving piezometer wells, pump wells, observation wells and dewatering wells will be required to assess the feasibility of control of mine inflow. The program should be guided by G. M. Meyer's recommendations as well as these points:

   - examine geologic features in surface exposures.
   - examine existing groundwater control and monitoring systems.
   - examine available borehole logs.
   - assess selective geophysical tools and techniques for discovery of overburden contacts and bedrock permeability changes (cavities).
   - consider the above points, the data synthesis, sinkhole locations, input from individuals knowledgeable about the history of mine inflow problems and some idea of probable cost in deciding on the mine-inflow investigation.

2) The bedrock hydrogeology is complex as a result of four different bedrock compositions and several possible overburden aquifers.

3) Part of the land surface surrounding the mine site is underlain by Windsor Group evaporites which are associated with sinkholes, many of which are presently active.

4) Sinkholes in the region tend to preferentially follow geologic contacts and fracture structures. The contacts and tectonic fractures have largely controlled the pre-glacial valley location and thus, local infills of permeable overburden sand and gravel.

5) Prediction of future sinkhole activity is difficult, however investigation and detailed plotting of overburden stratigraphy and bedrock units will help identify the groundwater regime.

6) Conclusions and recommendations by G. M. Meyer are well taken.

7) Following the hydrological investigation, should it be determined that the mine inflow problem can be solved, a person should be made responsible for groundwater monitoring on an ongoing basis and continuity of the groundwater monitoring ensured.

In an appendix to the report, Mr. Vince Beckie outlined his general comments and recommendations for the field investigation. He noted that definition of aquifer extents, groundwater flow directions, and aquifer contacts was required as a first step in solving the mine water problems. Mr. Beckie commented that it is vital that groundwater recharge from surficial aquifers be controlled. His recommendations elaborated on the following points:

i) A test drilling program should be carried out.
ii) Groundwater flow nets, flow directions and water quality should be used to isolate major recharge sources. Overburden aquifer water should be pumped before it recharges the bedrock aquifer, using dewatering wells installed from surface.
iii) Methods to locate and dewater deep underground water source sites should be considered.

iv) Geophysical exploration methods should be considered to identify high permeability units.

v) Program cost should be considered (with regard to likely cost-benefits).

3.5 Computer Modelling

A simple computer model of the Gays River hydrological regime was prepared by Fracflow Consultants Inc. A summary report of their work, "Numerical Investigation of Groundwater Inflow, Gays River Mine, N. S." is included as Volume VII of this report.

The groundwater flow was modelled initially on a 111 km^2 regional scale and subsequently on a small mine scale of 16.8 km^2. The regional model was used to model the influence of the mine dewatering on regional groundwater flow and to identify the boundary head conditions for the small-region model. The CFEST (Coupled Fluid, Energy, and Solute Transport) computer program was used to model the groundwater flow. CFEST is a three-dimensional, finite element, computer program. Modelling was performed under steady-state conditions.

As very little data on material conductivities had been compiled at the time of the modelling, a number of estimations and assumptions were made to assign conductivities to the overburden and bedrock materials. Following the initial regional model run, the conductivities and area assigned to the cone of depression were adjusted to calibrate the model.

After calibration, the regional model resulted in a mine "flux" of 4,197 USgpm and the generated heads and gradients were reasonably comparable to the actual conditions.

The small region or mine scale model included elements to model the till overburden, sand overburden, trench, evaporites, carbonates, quartzites and a high permeability zone on the trench-gypsum contact. After some calibration by adjusting conductivities, a reasonable small-region model was prepared that resulted in a mine "flux" of 4,017 USgpm.

Mine inflow was then simulated for high recharge conditions by doubling the surface recharge rate and assigning the nodes adjacent to the Gays River fixed heads to simulate a saturated floodplain. These changes increased the mine "flux" to 4,098 USgpm, a relatively small change and not reflective of actual response.

A number of pathways for water flow were calculated. Some of the pathways do not correlate with the current understanding of the hydrologic and geologic environment.

A number of recommendations were made in the report to improve and utilize the model. However, due to the complex geologic and hydrologic environment, it is considered that preparation of an accurate, responsive model in which the mine operator will have confidence, will be a large task, and perhaps will never be completed. In addition, there is every possibility that each new hydrologic event will require recalibration of the model. The possible benefits of the use of the model are not considered to warrant further development of this model, given the uncertain prospect for success and significant costs involved.

4.0 SUMMARY AND CONCLUSIONS

The extensive work conducted during the progress of this study, and other hydrological investigations conducted during 1991, has demonstrated that the groundwater levels in the mine area can be controlled by drainage to the mine workings through screened boreholes. Additional screened drainholes will be required and a continuing drainhole installation program may be needed throughout the mining operation.

The work conducted during the summer has also conclusively shown that the Gays River is a source of recharge water to the mine inflow. This is a major advance in the understanding of the Gays River area hydrology as no previous investigation or study had documented any significant hydraulic connection between the river and the mine workings during normal river flow conditions.

The Gays River hydrology and mining environment is complex and difficult. During future operations, management of the groundwater will be one of the challenges facing the mine operators. Care and attention must be directed towards maintaining adequate drainage and reduction of recharge from surface to the overburden and bedrock aquifers.

5.0 RECOMMENDATIONS

Most of the recommendations presented in the reports on the five investigations have been outlined and summarized in the Discussion section of this Project Overview. The following outlines some general recommendations for consideration, should mining operations at the Gays River Mine be resumed.

1) Serious consideration should be given to engineering modifications to prevent inundation of the floodplain of the Gays River. A complete diversion of the river away from the mine workings would be ideal, however this may not be practicable. Efforts to control floodplain inundation by dikes, control structures or other methods to restrict river flow to its channel, or seal the floodplain and reduce infiltration, will reduce the peak mine inflows and groundwater rebounds formerly associated with heavy rainfall and river flood events. As well, the floodplain area should be checked regularly for sinkhole development and all floodplain sinkholes filled and sealed.

2) Adequate drainage of groundwater to the mine workings must be maintained by installation of a sufficient number of screened drainholes. The number of active drain holes should include substantial reserve drainage capacity.

3) Methods for cleaning drainhole screens and developing flow from drainholes must be established and used. Possible methods include cleaning with high pressure air or water nozzles, surging with compressed air, and the use of packers to isolate and surge a particular section of the drainhole screen.

4) The intake of suspended solids with the mine discharge water should be monitored, controlled and kept to a minimum.

5) A field investigation to locate and place shallow dewatering wells in the area between the mine workings and the river north to northwest of 118 could be carried out. Placement of the screens would be in permeable sands or in karsted, permeable gypsum at the base of the overburden. The purpose of these wells would be to intercept water flow within the drawdown cone that would otherwise drain to the mine workings.

6) Echo sounder surveys to detect and monitor river bottom sinkholes in the Gays River should be carried out regularly, possibly quarterly.

7) Efforts should be made to locate, survey and document all sinkhole development. Annual airphotos and interpretation by qualified personnel should be considered.

8) A water chemistry sampling program could be established as outlined in Volume V.

9) Groundwater monitoring, as has been conducted to date, should be continued. Serious consideration should be given to installation of continuous instrumentation for monitoring key wells and underground pressure monitoring points. As well, installation of a flowmeter to monitor discharge from the central mine area should be considered.

10) Consideration should be given to the installation of additional monitoring wells in areas of the trench-gypsum permeable zone where water levels are not well monitored.

11) Further investigation of seepage from the river is warranted. Well points, mini-piezometers, and seepage tests could be utilized to define seepage areas and quantities.

12) The search for a simple, accurate method or flowmeter to monitor drainhole flow rates should be continued.

13) Consideration should be given to hiring a full time hydrologist to look after all hydrological programs.

6.0 REFERENCES

1. Martec Limited, (July 1991) Gays River Discharge Measurements and Stream Flow Gauging

2. Martec Limited, (November 1989) Gays River Continuity Survey

3. Martec Limited, (January 1991) Investigation into the Hydraulic Connection Between Underground Operations and Taylors Pond

APPENDIX A

MINUTES OF PHASE II PANEL OF EXPERTS MEETING

Nova Scotia MDA Project

"Control of Groundwater Hazard, Gays River Mine, N.S."

Phase II - Expert Panel - Meeting Notes

On May 13 - 14, 1991, a panel of 'experts' was convened to examine, discuss and put forward suggestions regarding the mine water problems currently being experienced by the Gays River Mine, Nova Scotia. The panel consisted of the following people: Chairman - Tim Aston (CANMET - MRL), Westminer Gays River Mine - Tom Lamb, Roger Levesque and Joe Campbell, Golder Assoc. - Trevor Carter and Rob Blair, Nolan Davis & Assoc. - Fred Baechler, Jacques Whitford & Assoc. - Dave MacFarlane, Fracflow Consultants Inc. - John Gale, Porter Dillon Ltd. - Jim Fraser, Leggette, Brashears & Graham Inc. - Russell Slayback. Also present for part of the time were: Dave Olszowiec (Westminer, Gays River Mine) and Don Jones, Nova Scotia Department of Mines and Energy.

On May 13, 1991, the panel members visited the underground workings (in particular: the 118 Sump, the 846 area to see the recent mud flow and the trench material - both drained and damp, as well as the use of fibre shotcrete). A detailed tour of the surface area was also made to look at sinkholes, areas with a history of sinkholes (backfilled), the discharge weir and the tailings pond. Discussions were also held regarding the mine geology, mining method, dewatering techniques and the proposed dewatering program to be undertaken by Mobile Aardvark Drilling.

On May 14, a meeting was convened to discuss the water problems. In addition to the site visit, each panel member was sent the copy of a report entitled "Gays River Mine Dewatering and Water Inflow Prevention" prepared by Gary Meyer.

The meeting was essentially split up into two main sessions:

Morning - Discussion regarding the source of the water.

Afternoon - Discussion regarding how to confirm the water source and propose (in ranked priority) monitoring programs which could be implemented to confirm the principle water source(s)

identified. In addition, the overall mine water problem was discussed.

Figure 1 shows a schematic representation across the deposit. In general, it was agreed that a 'flow conduit' exists along the interface between the trench material and the cavernous (karst) anhydrite/gypsum formation. The water in the anhydrite formation is thought to come from a variety of sources: regional recharge, partial recharge from the river, sinkholes as well as a component from the overlying surficial deposits. The footwall carbonate and quartzites, may contribute a very small component, but this was considered to be negligible. Some flow may also occur across the trench material, particularly near the base or where it narrows. Similarly, a small recharge component may also occur via the trench/surficial sediment interface. However, it was felt that the water primarily originated from the anhydrite formation.

Much discussion centred around the recharge mechanism to the anhydrite formation. It was felt that a significant base component originated from the regional catchment area of the anhydrite outcrop. This could take place via a regional karst network or a specific number of sinkholes, similar to that seen at Taylors Pond. It was considered unlikely that the river contributed directly to the problem, although seasonal variations in pumping rates, suggests that when the river covers the flood plain, additional water does enter the workings either via sinkholes in the flood plain or via the surficial sediments, feeding directly into the karst anhydrite formation or the "conduit" which is thought to exist along the anhydrite/trench contact.

In addition, it was also considered that the bed of the river could not reasonably be considered impermeable along its entire length and that the band of hard clay located in the surficial deposits is not uniformly impermeable across the entire area, but fractured in places. Consideration was also given to water feeding from the tailings pond, via surficial sands into the anhydrite formation, but again this was not thought to be a major source.

With these considerations in mind the following priority was established for instrumentation/monitoring requirements:

1 a) Develop a data base of head and flow rate information from existing and proposed underground boreholes. This would involve installing pressure gauges and/or flow meters. In particular, it is considered important to monitor (in detail) the flow rates in the three holes feeding the 118 sump. This could be done using magnetic or doppler flow meters.

1 b) Undertake a detailed hydrochemical study to determine the source of the water. In addition to implementing a detailed hydrochemical "snap shot" from both potential surface and underground sources, isotope methods should also be used. In particular, the isotope testing is not necessary on all the samples, but should be focused on the "first water" encountered from the proposed Aardvark holes to be drilled into the anhydrite/trench contact. It should be noted that in this case "first water" means exactly that - the samples must be obtained from the very first water to be made by the hole, in order to determine whether it is fossil or recent.

2) A program should be implemented to investigate the regional recharge regime of the anhydrite formations feeding the mine area. The program should concentrate on the location of potential sinkholes (either by field mapping or via aerial photographic techniques), which could be feeding water, via a series of base components, in a manner similar to that seen at Taylors Pond.

3) Start investigating the application of numerical modelling techniques. The use of modelling techniques could provide considerable insight into the understanding of the piezometric regime existing around the mine and potentially provide additional information on target areas for dewatering holes.

4) Undertake a detailed monitoring program involving the installation and monitoring of piezometers to determine the near surface flow regime in the surficial sediments as well as the "deeper" flow regime in the anhydrite formation. It is proposed

that approximately 20 holes should be drilled and installed with piezometers. Simultaneously, the opportunity should also be used to establish a detailed understanding of the surficial sediment composition. At least one piezometer should be installed in the trench material. The piezometer network could also be used to establish the extent of the drawdown cone existing around the mine as well as monitor the effects and identify the source of seasonal variations in flow rates. Also, in addition to the piezometer network a series of 'sand' or 'jet' points should be installed along the river to assess the amount of leakage or recharge to/from the surficial sediments.

5) Concern was expressed regarding catastrophic inflows or inrushes to the mine workings. The mine currently has a very good program "in place" to monitor both catastrophic events and problems within the workings. The panel suggested that 'low pressure' piezometers could be installed in the trench material and used as an addition warning tool. However, it should be noted that a period of 'research' would be initially required in order to calibrate the proposed system. In addition, it was felt that the potential flow characteristics of the trench material should also be determined.

6) Detailed geophysical surveys were not considered a high priority by the panel, although they could be used to better delineate the trench profile and look for karst structures or sand channels in the surficial sediments. Use could be made of 'Hammer Seismic' techniques for the determination of sand channels and sinkholes in the flood plain.

7) Additional tracer studies in the river or elsewhere were not immediately recommended, until a better understanding of the flow regime was attained or specific target areas identified.

8) The provision of extra dewatering capacity by utilising existing surface production and observation holes as outlined in Section 8 (d) of Gary Meyer's report was not considered a high priority item. In addition, consideration could also be given to

grouting surface exploration holes which penetrate the trench, but once again this was not considered a priority item.

Additional Items

1) At the start of the two day session, the mine announced that Mobile Aardvark would be coming on site within the next two weeks to undertake the drilling of a series of underground drainage holes. The panel expressed concern about Aardvark's intention to use plastic screens in the holes, in view of the highly 'destructive' environment that could be expected in the conduit at the trench/anhydrite interface. Considerable time was spent by the panel discussing the type and size of the screens that should be installed. It was strongly recommended that a size analysis of the sand being washed out of the 118 sump holes be undertaken before any screens are installed.

In conclusion of this point, it was suggested that the mine continue with the proposed program using plastic screens, but serious consideration should be given to the use of stainless steel screens, if problems start to occur.

T. R. C. Aston
Research Program Advisor
CANMET - MRL

May 17, 1991

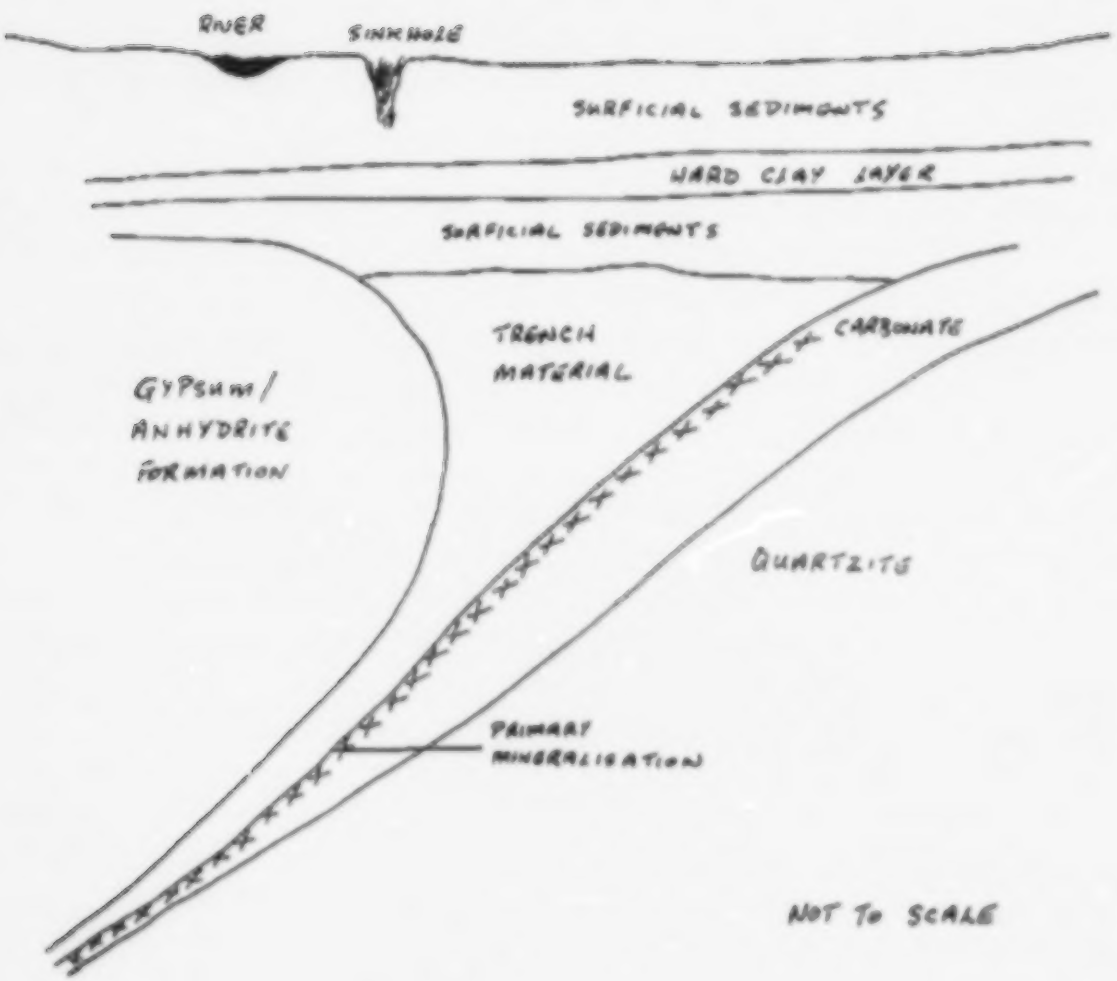

Figure 1 - Schematic cross section across the deposit.

APPENDIX B

1991 DAILY DEEP WELL GROUNDWATER MONITORING DATA

GAYS RIVER MINE DAILY GROUNDWATER MONITORING JANUARY 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Cons. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Jan							0.0			3,987	3,987
02-Jan	446.21	449.21	456.61	479.39	515.52	35,487	1.0			3,844	3,844
03-Jan	444.68	447.57			515.48	30,664	0.0			4,083	4,083
04-Jan	444.12	dry@446.72			515.44	26,269	0.0			4,146	4,146
05-Jan							0.6			4,044	4,044
06-Jan							1.8			3,902	3,902
07-Jan	440.98	dry@446.72			515.37	19,558	0.2			3,515	3,515
08-Jan	442.20	dry@446.72			515.38	20,443	0.0			3,500	3,500
09-Jan	445.68	dry@446.72	456.08	479.29	515.37	19,558	2.5			3,446	3,446
10-JAN-8am	449.60	450.84									
10-JAN-1pm	449.71	451.15			515.35	17,861	8.2			3,068	3,068
11-JAN10am	440.77	dry@446.72									
11-JAN-1pm	443.79	dry@446.72			515.35	17,861	0.0			3,794	3,794
12-Jan	457.12	457.36					10.6			1,982	1,982
13-Jan	462.25	462.57					0.9			2,242	2,242
14-JAN-8am	454.00	455.65			515.35	17,861					
14-JAN-1pm	450.99	453.32					0.0			4,138	4,138
15-Jan	450.22	451.21					3.4			3,424	3,424
16-JAN-8am	453.41	454.32									
16-JAN-1pm	453.81	454.63	456.64	479.31	515.30	14,024	15.1			2,860	2,860
17-JAN-8am	455.58	456.44									
17-JAN-1pm	455.00	455.99			515.50	33,021	22.2			2,927	2,927
18-JAN-8am	454.22	455.17									
18-JAN-1pm	454.18	455.12			515.80	82,401	1.0			3,338	3,338
19-Jan							5.0			2,995	2,995
20-Jan							0.4			3,046	3,046
21-JAN-8am	456.50	457.41									
21-JAN-1pm	457.21	458.10			515.78	78,230	0.0			2,946	2,946
22-JAN10am	449.26	451.57									
22-JAN-1pm	448.37	450.58			515.82	86,706	0.0			3,870	3,870
23-JAN-8am	443.36	dry@446.72									
23-JAN-1pm	442.90	dry@446.72	456.42	479.14	515.63	51,068	1.0			3,816	3,816
24-Jan	444.77	dry@446.72			515.51	34,240	1.7			3,514	3,514
25-Jan	445.25	dry@446.72			515.44	26,269	0.0			3,423	3,423
26-Jan	441.73						0.0			3,650	3,650

GAYS RIVER MINE DAILY GROUNDWATER MONITORING JANUARY 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Conn. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
27-Jan							1.4			3,433	3,433
28-JAN-8am	441.35										
28-JAN-1pm	441.36	dry@446.72			515.32	15,490	3.7			3,379	3,379
29-Jan	441.38	dry@446.72			515.31	14,746	0.0			3,419	3,419
30-Jan	440.86	dry@446.72	455.92	479.34	515.29	13,324	2.0			3,425	3,425
31-Jan	440.63	dry@446.72			515.43	25,235	24.4			3,257	3,257

Monthly Equivalent Precipitation (mm) 107.1

Monthly Average Pumping (USgpm) 3,433

Notes: Frequent plugging off of main 118 Drainholes during January.

GAYS RIVER MINE DAILY GROUNDWATER MONITORING FEBRUARY 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Cons. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Feb	441.10	dry@446.72			515.53	36,761	1.4			3,478	3,478
02-Feb							0.0			3,394	3,394
03-Feb							0.0			3,421	3,421
04-Feb	442.75	dry@446.72			515.50	33,021	0.0			3,314	3,314
05-Feb	443.40	dry@446.72			515.47	29,526	0.5			3,352	3,352
06-Feb	445.42	dry@446.72	455.83	479.31	515.44	26,269	0.0			3,279	3,279
07-Feb	443.23	dry@446.72			515.42	24,227	3.0			3,466	3,466
08-Feb	443.54	dry@446.72			515.41	23,243	0.0			3,376	3,376
09-Feb							0.0			3,279	3,279
10-Feb							0.0			3,420	3,420
11-Feb	442.14	dry@446.72			515.39	21,352	1.8			3,323	3,323
12-Feb	441.17	dry@446.72			515.39	21,352	0.0			3,273	3,273
13-Feb	442.82	dry@446.72	455.30	479.46	515.36	18,698	0.0			3,180	3,180
14-Feb	444.50	dry@446.72			515.32	15,490	29.7			3,032	3,032
15-Feb	442.27	dry@446.72			515.56	40,750	2.9			3,409	3,409
16-Feb							2.1			3,132	3,132
17-Feb							1.1			3,043	3,043
18-Feb	441.84	dry@446.72			515.70	62,858	0.0	240		3,118	3,358
19-Feb	443.68	dry@446.72			515.62	49,506	1.1	240		3,213	3,453
20-Feb	443.16	dry@446.72	455.50	479.28	515.56	40,750	14.3	240		3,146	3,386
21-Feb	442.27	dry@446.72			515.69	61,081	0.0	240		3,178	3,418
22-Feb	441.18	dry@446.72			515.66	55,936	0.4	240		3,134	3,374
23-Feb							0.0	240		3,014	3,254
24-Feb							0.0	240		3,063	3,303
25-Feb	442.77	dry@446.72			515.46	28,414	0.4	240		3,005	3,245
26-Feb	443.61	dry@446.72			515.40	22,285	0.0	240		3,107	3,347
27-Feb	445.21	dry@446.72	455.66	479.10	515.35	17,861	0.6	240		3,060	3,300
28-Feb	448.94	449.81			515.31	14,746	0.6	240		2,981	3,221

Monthly Equivalent Precipitation (mm) 59.9

Monthly Average Pumping (USgpm) 3,315

Notes: 825 Sump commissioned in February.
Discharge of 825 Sump Estimated at an average of 240 USgpm.

GAYS RIVER MINE DAILY GROUNDWATER MONITORING MARCH 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Cons. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-MAR-8am	449.52										
01-MAR-1pm	448.55	450.12			515.29	13,324	1.5	240		3,059	3,299
02-Mar	445.66	447.19					21.3	240		3,290	3,530
03-Mar	443.35	dry@446.72					trace	240		3,336	3,576
04-Mar	443.96	dry@446.72			515.79	80,299	38.6	240		3,242	3,482
05-MAR-9am	444.56	dry@446.72									
05-MAR-1pm	444.83	dry@446.72			516.29	230,369	5.6	240		3,668	3,908
06-Mar	446.32	dry@446.72	454.88	478.74	516.26	218,575	0.0	240		3,420	3,660
07-MAR-9am	451.70	452.83									
07-MAR-1pm	451.56	453.18			515.95	118,077	10.8	240		3,216	3,456
07-MAR-4pm	451.43										
08-MAR-8am	453.19										
08-MAR-1pm	453.52		456.24		515.95	118,077	0.0	240		3,582	3,822
09-Mar	453.84		456.62	478.84			0.7	240		3,659	3,899
10-Mar	453.20		456.59	478.57			4.8	240		3,770	4,010
11-MAR-8am	453.27		456.57	478.63							
11-MAR-1pm	453.30		456.62	478.65	515.63	51,068	4.3	240		3,740	3,980
12-Mar	453.97		456.61		515.56	40,750	2.1	240		3,771	4,011
13-Mar	454.00	455.37	456.76	478.51	515.54	38,062	0.2	240		3,771	4,011
14-Mar	453.59		456.38	478.24	515.56	40,750	0.4	240		3,794	4,034
15-Mar	452.73		456.12	478.27	515.53	36,761	0.2	240		3,900	4,140
16-Mar							trace	240		3,615	3,855
17-Mar							0.0	240		3,700	3,940
18-Mar	450.69		455.68	478.18	515.40	22,285	0.0	240		3,779	4,019
19-Mar	449.10		456.68	478.46	515.44	26,269	20.1	240		3,841	4,081
20-Mar	448.25	450.10	455.80	478.56	515.71	64,667	0.2	240		3,838	4,078
21-Mar	449.99		455.86	478.18	515.71	64,667	trace	240		3,726	3,966
22-Mar	449.18		455.89	477.92	515.60	46,470	0.0	240		3,837	4,077
23-Mar							0.0	240		3,822	4,062
24-Mar							13.0	240		3,796	4,036
25-Mar	448.98		455.95	477.69	515.41	23,243	trace	240		3,850	4,090
26-Mar	448.84		455.78	477.95	515.38	20,443	0.0	240		3,756	3,996
27-Mar	448.34	449.10	455.69	477.92	515.39	21,352	0.0	240		3,875	4,115
28-Mar	448.87		455.75	477.92	515.44	26,269	11.7	240		3,849	4,089
29-Mar							0.0	240		3,943	4,183

GAYS RIVER MINE DAILY GROUNDWATER MONITORING MARCH 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Cons. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
30-Mar							14.6	240		3,961	4,201
31-Mar							trace	240		3,912	4,152

Monthly Equivalent Precipitation (mm) 150.1

Monthly Average Pumping (USgpm) 3,928

Notes: Discharge of 825 Sump Estimated at an average of 240 USgpm.

GAYS RIVER MINE DAILY GROUNDWATER MONITORING APRIL 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Cons. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Apr	448.98		455.96	477.70	515.71	64,667	2.3	240		3,963	4,203
02-Apr	447.72		455.81	477.65	515.62	49,506	2.2	240		4,078	4,318
03-Apr	448.84	449.34	456.01	477.54	515.55	39,392	0.0	240		3,998	4,238
04-Apr	448.38		455.39	477.44	515.53	36,761	0.0	240		3,967	4,207
05-Apr	443.13		454.49	477.56	515.50	33,021	0.0	240		3,949	4,189
06-Apr							trace	240		3,806	4,046
07-Apr							1.8	240		3,628	3,868
08-Apr	444.16		455.41	477.54	515.56	40,750	0.0	240		3,558	3,798
09-Apr	441.58		455.35	477.52	515.55	39,392	9.6	240		3,764	4,004
10-Apr	441.86	dry@446.72	455.57	477.48	515.68	59,335	1.4	240		3,824	4,064
11-Apr	440.82		455.22	477.49	515.71	64,667	2.2	240		3,615	3,855
12-Apr	440.46		455.10	477.29	515.71	64,667	1.6	240		3,643	3,883
13-Apr							0.0	240		3,513	3,753
14-Apr							0.0	240		3,410	3,650
15-Apr	440.36		455.08	477.32	515.49	31,829	0.0	240		3,551	3,791
16-Apr	440.37		455.00	477.40	515.47	29,526	1.8	240		3,401	3,641
17-Apr	440.35	dry@446.72	455.20	477.33	515.46	28,414	0.0	240		3,341	3,581
18-Apr	440.24		455.34	477.20	515.44	26,269	0.0	240		3,329	3,569
19-Apr	440.20		454.97	477.24	515.41	23,243	0.0	240		3,203	3,443
20-Apr							trace	240		3,244	3,484
21-Apr							29.7	240		3,294	3,534
22-Apr	440.10		454.90	477.44	515.82	86,706	34.0	240		3,760	4,000
23-Apr	440.20		455.50	477.40	516.21	199,761	trace	240		3,406	3,646
24-Apr	443.33	dry@446.72	455.79	477.31	515.99	128,953	0.0	240		3,469	3,709
25-Apr	440.20		455.64	477.28	515.81	84,536	0.0	240		3,608	3,848
26-Apr	440.23		455.81	477.13	515.70	62,858	0.0	240		3,561	3,801
27-Apr							0.0	240		3,806	4,046
28-Apr							0.0	240		3,440	3,680
29-Apr	451.35		456.03	477.08	515.51	34,240	0.0	240		3,149	3,389
30-Apr	453.74		456.37	477.05	515.44	26,269	0.0	240		3,755	3,995

Monthly Equivalent Precipitation (mm) 86.6

Monthly Average Pumping (USgpm) 3,841

Notes: Discharge of 825 Sump Estimated at an average of 240 USgpm.

GAYS RIVER MINE DAILY GROUNDWATER MONITORING MAY 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Conc. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-May	454.86	456.17	456.83	477.04	515.42	24,227	trace	240		3,913	4,153
02-May	454.80		456.72	477.21	515.38	20,443	8.4	240		3,974	4,214
03-May	455.77		457.05	477.19	515.57	42,137	69.6	240		4,015	4,255
04-May							0.9	240		4,140	4,380
05-May							trace	240		4,050	4,290
06-May	457.98		459.55	476.87	515.75	72,222	0.0	240		4,132	4,372
07-May	457.69		459.61	476.87	515.67	57,620	23.8	240		4,503	4,743
08-May	458.36	459.47	459.89	476.83	515.75	72,222	0.0	240		4,233	4,473
09-May	451.49		456.94	476.72	515.72	66,508	0.0	240		4,504	4,744
10-May	456.50	457.86	458.03	476.76	515.63	51,068	0.0	240		4,261	4,501
11-May	458.50	459.87					0.0	240		3,994	4,234
12-May	459.50	460.88					6.8	240		4,058	4,298
13-May	459.99	461.59	460.66	476.85	515.46	28,414	trace	240		4,125	4,365
14-May	460.32	461.86	460.91	476.92	515.41	23,243	trace	240		4,232	4,472
15-May	459.78	461.40	460.39	476.72	515.38	20,443	0.0	240		4,390	4,630
16-May	459.50	461.17	460.29	476.73	515.31	14,746	0.0	240		4,382	4,622
17-May	459.91	461.43	460.06	476.77	515.25	10,743	1.2	240		4,095	4,335
18-May	460.35	461.80					10.8	240		4,285	4,525
19-May	461.02	463.51					0.0	240		4,351	4,591
20-May	460.57	462.05					0.0	240		4,392	4,632
21-May	460.58	462.04	459.68	476.67	515.32	15,490	0.0	240	200	4,229	4,669
22-May	460.62	462.09	459.73	476.56	515.30	14,024	0.0	240	200	4,163	4,603
23-May	460.78	462.24	459.70	476.56	515.28	12,647	0.0	240	200	4,136	4,576
24-May	460.88	462.39	459.81	476.60	515.27	11,991	3.6	240	200	4,115	4,555
25-May	460.46	461.97					0.0	240		4,345	4,585
26-May	460.65	462.14					0.0	240		4,293	4,533
27-May	461.02	462.56	460.32	476.35	515.28	12,647	3.6	240	100	4,189	4,529
28-May	461.72	463.22	460.48	476.45	515.30	14,024	2.8	240	200	4,189	4,629
29-May	462.09	463.59	461.00	476.40	515.35	17,861	trace	240	200	4,186	4,626
30-May	463.11	464.51	461.63	476.41	515.31	14,746	0.0	240	200	4,259	4,699
31-May	463.94	465.35	461.66	476.32	515.28	12,647	0.2	240	200	4,255	4,695

Monthly Equivalent Precipitation (mm) 131.7

Monthly Average Pumping (USgpm) 4,501

Notes: Discharge of 825 Sump Estimated at an average of 240 USgpm.
Inflow from 846 Stope on May 8, 1991

GAYS RIVER MINE DAILY GROUNDWATER MONITORING JUNE 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Cons. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Jun	463.60	464.97	461.87				0.2	600	100	4,400	5,100
02-Jun	463.52	464.92	461.92				trace	600	0	4,475	5,075
03-Jun	463.72	465.14	459.80	476.40	515.24	10,150	1.8	600	100	4,243	4,943
04-Jun	460.73	462.13	458.15	476.31	515.22	< 10,000	0.0	600	200	4,544	5,344
05-Jun	460.95	462.23	459.22	476.25	515.21	< 10,000	1.2	600	200	4,341	5,141
06-Jun	461.96	463.21	459.46	476.20	515.21	< 10,000	0.9	600	200	4,270	5,070
07-Jun	462.53	463.74	459.12	476.18	515.21	< 10,000	0.0	600	200	3,874	4,674
08-Jun	459.01	460.37	456.70				trace	1,217	100	4,123	5,440
09-Jun	459.88	461.21	457.92				0.0	1,253	0	4,161	5,414
10-Jun	458.65	460.01	457.35	476.42	515.21	< 10,000	0.0	1,486	100	4,112	5,698
11-Jun	458.18	459.42	455.67	476.37	515.19	< 10,000	0.0	1,359	200	4,084	5,643
12-Jun	456.75	458.10	455.92	476.24	515.20	< 10,000	0.6	1,448	200	4,106	5,754
13-Jun	457.40	458.72	456.11	476.27	515.21	< 10,000	4.4	1,087	200	4,386	5,673
14-Jun	456.10	457.74	455.82	476.24	515.23	< 10,000	1.2	946	200	4,546	5,692
15-Jun	452.12	453.69	453.90	476.02			0.0	1,022	160	4,618	5,800
16-Jun	445.72	448.09	453.09				0.0	1,213	0	4,359	5,572
17-Jun	442.67	447.45	454.13	475.86	515.22	< 10,000	1.6	1,089	40	3,971	5,100
18-Jun	441.29	447.37	452.58	474.45	515.21	< 10,000	0.0	1,019	200	3,704	4,923
19-Jun	440.30	447.32	452.31	476.07	515.21	< 10,000	0.2	1,075	200	3,475	4,750
20-Jun	440.19	dry@447.39	452.20	476.07	515.21	< 10,000	trace	1,182	200	3,285	4,667
21-Jun	440.13	dry@447.37	451.84	477.36	515.21	< 10,000	0.0	1,130	200	3,356	4,686
22-Jun	440.09	dry@447.37	451.62	476.47			0.4	1,144	160	3,215	4,519
23-Jun	440.11	dry@447.37	451.59	476.53			0.6	1,132	0	2,986	4,118
24-Jun	440.09	dry@447.37	451.60	476.16	515.20	< 10,000	0.0	1,104	40	2,937	4,081
25-Jun	445.08	dry@447.37	451.53	475.10	515.20	< 10,000	0.0	1,193	200	2,592	3,985
26-Jun	439.96	dry@447.37	451.25	476.06	515.20	< 10,000	3.2	1,208	200	2,285	3,693
27-Jun	439.22	dry@447.37	451.23	477.30	515.21	< 10,000	0.0	1,249	200	2,666	4,115
28-Jun	439.22	dry@447.37	451.89	476.20	515.21	< 10,000	2.0	1,181	200	2,643	4,024
29-Jun	439.18	dry@447.37	451.60	476.13			trace	1,242	160	2,511	3,913
30-Jun	439.16	dry@447.37	451.17	476.22			trace	1,284	0	2,667	3,951

Monthly Equivalent Precipitation (mm) 18.3

Monthly Average Pumping (USgpm) 4,885

Notes: 825 Sump discharge estimate revised to 600 USgpm June 1 - 7, 1991
Pump hours used to estimate 825 Sump discharge June 8 - 30, 1991.

GAYS RIVER MINE DAILY GROUNDWATER MONITORING JULY 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Cons. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Jul	439.14	dry@447.37	451.27	476.27			0.0	1,251	0	2,587	3,838
02-Jul	439.13	dry@447.37	451.40	476.53	515.21	< 10,000	0.0	1,217	40	2,622	3,879
03-Jul	439.09	dry@447.37	451.34	476.18	515.20	< 10,000	0.0	1,223	200	2,393	3,816
04-Jul	439.06	dry@447.37	451.10	476.14	515.20	< 10,000	0.0	1,251	200	2,644	4,095
05-Jul	439.07	dry@447.37	451.47	475.79	515.20	< 10,000	0.0	1,196	200	2,551	3,947
06-Jul	439.05	dry@447.37	451.25	475.33			0.0	1,214	160	2,702	4,076
07-Jul	439.03	dry@447.37	451.21	475.77			0.0	1,200	0	2,776	3,976
08-Jul	441.33	dry@447.37	451.34	475.40	515.20	< 10,000	0.6	1,162	40	2,378	3,580
09-Jul	447.50	dry@447.37	451.32	475.16	515.20	< 10,000	trace	1,199	200	2,180	3,579
10-Jul	451.56	451.88	451.49	475.14	515.19	< 10,000	0.0	1,303	200	1,700	3,203
11-Jul	454.15	454.46	452.00	475.37	515.19	< 10,000	0.0	1,224	200	1,809	3,233
12-Jul	456.47	456.44	452.90	476.51	515.25	10,743	0.0	1,246	200	1,760	3,206
13-Jul	454.49	455.27	452.43	475.90	515.26	11,356	trace	1,241	160	2,271	3,672
14-Jul	452.36	453.24	452.17	474.86	515.23	< 10,000	16.2	1,246	0	2,606	3,852
15-Jul	451.19	452.12	452.02	474.96	515.28	12,647	3.0	1,230	40	2,607	3,877
16-Jul	450.82	451.35	451.94	474.85	515.26	11,356	0.0	1,225	200	2,430	3,855
17-Jul	449.87	450.24	451.62	474.89	515.24	10,150	0.0	1,231	200	2,452	3,883
18-Jul	449.56	449.88	451.54	474.99	515.22	< 10,000	0.2	1,286	200	2,496	3,982
19-Jul	449.00	449.27	451.19	475.20	515.21	< 10,000	0.0	1,288	160	2,666	4,114
20-Jul	447.77	448.07	451.11	475.59	515.21	< 10,000	0.0	1,441	0	2,804	4,245
21-Jul	447.53	447.78	451.13	475.46	515.21	< 10,000	5.6	1,419	0	2,794	4,213
22-Jul	447.77	447.98	451.22	475.34	515.21	< 10,000	0.0	1,412	0	2,690	4,102
23-Jul	448.72	448.96	451.02	474.65	515.20	< 10,000	trace	1,487	0	2,559	4,046
24-Jul	448.27	448.59	450.73	475.10	515.21	< 10,000	0.2	1,456	0	2,598	4,054
25-Jul	439.01	dry@447.37	450.37	475.11	515.18	< 10,000	0.0	1,428	0	3,033	4,461
26-Jul	439.04	dry@447.37	450.02	474.60	515.05	< 10,000	2.4	1,438	0	2,781	4,219
27-Jul	438.80	dry@447.37	449.75	474.03	515.08	< 10,000	34.8	1,410	0	2,587	3,997
28-Jul	438.70	dry@447.37	449.28	474.76	515.08	< 10,000	0.0	1,389	0	2,710	4,099
29-Jul	442.17	dry@447.37	448.97	475.18	515.06	< 10,000	0.0	1,310	40	2,446	3,796
30-Jul	443.30	dry@447.37	448.07	475.55	515.05	< 10,000	0.0	1,296	150	2,379	3,825
31-Jul	438.71	dry@447.37	447.29	476.00	515.04	< 10,000	1.1	1,275	30	2,507	3,812

Monthly Equivalent Precipitation (mm) 64.1

Monthly Average Pumping (USgpm) 3,888

Notes: Pump hours used to estimate 825 Sump discharge July 1 – 19, flowmeter used to measure discharge beginning July 19, 1991
Tailings pond discharge diversion begun July 25, 1991. Weir flows estimated on July 16 & 17.

GAYS RIVER MINE DAILY GROUNDWATER MONITORING AUGUST 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Mtn Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Cons. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Aug	445.17	dry@447.37	446.64	475.28	515.04	< 10,000	0.4	1,253	0	2,350	3,603
02-Aug	444.75	dry@447.37	448.04	474.79	515.07	< 10,000	5.2	1,236	0	2,533	3,769
03-Aug	438.69	dry@447.37	446.01	474.34	515.05	< 10,000	trace	1,235	0	2,613	3,848
04-Aug	438.58	dry@447.37	445.31	474.11	515.04	< 10,000	1.0	1,209	0	2,457	3,666
05-Aug	438.55	dry@447.37	444.78	473.93	515.04	< 10,000	16.3	1,192	0	2,474	3,666
06-Aug	438.52	dry@447.37	445.11	473.47	515.09	< 10,000	0.4	1,164	20	2,305	3,489
07-Aug	438.51	dry@447.37	444.66	473.08	515.15	< 10,000	0.0	1,161	130	2,217	3,508
08-Aug	438.50	dry@447.37	444.53	472.83	515.13	< 10,000	0.0	1,132	60	2,197	3,389
09-Aug	438.39	dry@447.37	444.41	472.65	515.08	< 10,000	0.0	1,121	80	2,153	3,354
10-Aug	438.41	dry@447.37	444.67	472.56	515.07	< 10,000	4.2	1,140	100	1,950	3,190
11-Aug	438.43	dry@447.37	444.59	472.40	515.13	< 10,000	26.7	1,130	0	2,241	3,371
12-Aug	438.41	dry@447.37	444.59	472.41	515.29	13,324	0.0	1,112	40	2,181	3,333
13-Aug	438.41	dry@447.37	444.58	473.25	515.29	13,324	0.0	1,132	150	1,972	3,254
14-Aug	438.48	dry@447.37	445.11	474.43	515.21	< 10,000	0.0	1,190	120	2,081	3,391
15-Aug	441.54	dry@447.37	447.01	475.30	515.12	< 10,000	1.3	1,277	75	2,197	3,549
16-Aug	438.55	dry@447.37	447.81	474.88	515.09	< 10,000	trace	1,278	100	2,134	3,512
17-Aug	438.60	dry@447.37	447.98	474.18	515.07	< 10,000	0.0	1,322	70	2,287	3,679
18-Aug	438.63	dry@447.37	447.78	473.78	515.05	< 10,000	trace	1,309	0	2,387	3,696
19-Aug	442.67	dry@447.37	447.19	473.15	515.06	< 10,000	53.4	1,326	30	2,323	3,679
20-Aug	441.82	dry@447.37	446.48	472.92	515.43	25,235	0.0	1,371	80	2,525	3,976
21-Aug	441.32	dry@447.37	447.09	473.90	515.61	47,973	17.4	1,318	100	2,396	3,814
22-Aug	441.77	dry@447.37	448.78	474.75	515.68	59,335	0.6	1,358	110	2,440	3,908
23-Aug	438.67	dry@447.37	450.46	475.39	515.70	62,858	0.0	1,413	100	2,495	4,008
24-Aug	442.17	dry@447.37	451.45	475.76	515.63	51,068	0.0	1,468	75	2,622	4,165
25-Aug	443.30	dry@447.37	451.86	475.93	515.49	31,829	0.0	1,503	0	2,851	4,354
26-Aug	444.38	dry@447.37	452.27	475.80	515.34	17,047	0.0	1,486	30	2,808	4,324
27-Aug	438.82	dry@447.37	452.36	475.34	515.21	< 10,000	0.0	1,496	110	2,567	4,173
28-Aug	442.17	dry@447.37	452.32	474.86	515.17	< 10,000	0.8	1,511	120	2,478	4,109
29-Aug	441.62	dry@447.37	452.37	475.08	515.34	17,047	0.0	1,529	120	2,435	4,084
30-Aug	438.77	dry@447.37	452.33	474.60	515.39	21,352	0.0	1,531	120	2,568	4,219
31-Aug	442.02	dry@447.37	452.36	474.37	515.36	18,698	0.4	1,528	75	2,750	4,353

Monthly Equivalent Precipitation (mm) 128.1

Monthly Average Pumping (USgpm) 3,756

Notes: Flowmeter used to measure 825 Sump discharge.
Tailings pond discharge diversion in effect throughout August.

GAYS RIVER MINE DAILY GROUNDWATER MONITORING SEPTEMBER 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Coss. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Sep	442.62	dry@447.37	452.54	474.29	515.31	14,746	3.2	1,525	0	2,912	4,437
02-Sep	442.62	dry@447.37	452.68	474.37	515.29	13,324	0.0	1,540	0	2,976	4,516
03-Sep	443.54	dry@447.37	452.87	472.61	515.25	10,743	0.0	1,542	30	2,958	4,530
04-Sep	441.71	dry@447.37	453.11	472.77	515.22	< 10,000	0.0	1,481	130	2,821	4,432
05-Sep	441.85	dry@447.37	453.19	472.85	515.14	< 10,000	trace	1,385	80	2,916	4,381
06-Sep	443.19	dry@447.37	453.16	473.12	515.06	< 10,000	16.8	1,352	120	2,809	4,281
07-Sep	443.52	dry@447.37	452.98	474.35	515.12	< 10,000	4.2	1,317	80	2,918	4,315
08-Sep	444.18	dry@447.37	453.11	473.97	515.26	11,356	trace	1,264	0	2,952	4,216
09-Sep	441.56	dry@447.37	453.09	474.70	515.26	11,356	0.0	1,224	30	3,250	4,504
10-Sep	437.97	dry@447.37	452.99	475.02	515.19	< 10,000	0.0	1,233	100	3,094	4,427
11-Sep	438.72	dry@447.37	452.70	475.88	515.14	< 10,000	17.7	1,215	100	3,048	4,363
12-Sep	443.07	dry@447.37	452.56	473.04	515.31	14,746	0.0	1,213	30	3,166	4,409
13-Sep	441.77	dry@447.37	452.49	474.27	515.34	17,047	0.0	1,481	140	2,818	4,419
14-Sep	438.64	dry@447.37	452.37	474.12	515.32	15,490	0.0	1,633	70	2,834	4,537
15-Sep	437.17	dry@447.37	452.41	474.11	515.33	16,257	0.0	1,562	0	2,993	4,555
16-Sep	444.20	dry@447.37	452.51	473.96	515.34	17,047	2.0	1,567	30	2,708	4,305
17-Sep	437.61	dry@447.37	452.54	473.97	515.33	16,257	0.5	1,569	100	3,078	4,747
18-Sep	439.97	dry@447.37	452.68	473.69	515.31	14,746	0.0	1,532	110	2,876	4,518
19-Sep	437.92	dry@447.37	452.59	473.57	515.29	13,324	20.0	1,528	110	2,964	4,602
20-Sep	441.40	dry@447.37	453.68	473.60	515.44	26,269	50.6	1,359	120	3,071	4,550
21-Sep	443.44	dry@447.37	453.28	473.66	516.18	188,970	trace	1,481	60	3,316	4,857
22-Sep	443.32	dry@447.37	453.67	474.23	516.16	181,980	0.0	1,483	0	3,502	4,985
23-Sep	448.42	dry@447.37	453.84	474.44	516.00	131,764	0.0	1,516	30	3,658	5,204
24-Sep	449.25	450.40	453.97	474.18	515.91	107,786	0.0	1,527	80	3,424	5,031
25-Sep	449.03	448.20	453.89	473.97	515.81	84,536	1.2	1,550	140	3,574	5,264
26-Sep	448.42	447.61	453.98	473.82	515.83	88,909	28.4	1,523	90	3,791	5,404
27-Sep	447.67	dry@447.37	453.94	473.71	516.22	203,441	trace	1,529	125	3,855	5,509
28-Sep	448.97	449.14	454.23	474.74	516.22	203,441	0.0	1,553	100	3,834	5,487
29-Sep	449.15	449.34	454.35	474.19	516.09	158,781	2.4	1,569	0	3,879	5,448
30-Sep	447.12	dry@447.37	454.42	473.85	515.97	123,441	0.2	1,569	0	4,516	6,085

Monthly Equivalent Precipitation (mm) 147.2

Monthly Average Pumping (USgpm) 4,744

Notes: Flowmeter used to measure 825 Sump discharge.
Tailings pond discharge diversion in effect until Sept. 15, 1991

GAYS RIVER MINE DAILY GROUNDWATER MONITORING OCTOBER 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hfx Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Ex. Conc. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Oct	439.42	dry@447.37	454.30	473.61	515.87	98,068	2.0	1,591	0	4,124	5,715
02-Oct	439.72	dry@447.37	454.36	473.52	515.82	86,706	35.0	1,562	90	4,186	5,838
03-Oct	439.74	dry@447.37	454.51	473.48	516.25	214,729	0.2	1,533	60	4,242	5,835
04-Oct	454.15	454.63	454.77	473.54	516.21	199,761	26.0	1,537	120	3,462	5,119
05-Oct	449.85	450.09	454.80	473.58	516.30	234,386	0.0	1,529	120	4,650	6,299
06-Oct	450.81	450.81	454.99	473.46	516.12	168,485	0.0	1,514	70	4,592	6,176
07-Oct	444.52	dry@447.37	454.93	473.09	516.10	161,976	21.5	1,521	30	4,704	6,255
08-Oct	444.37	dry@447.37	455.00	472.89	516.27	222,464	5.6	1,493	60	4,501	6,054
09-Oct	444.37	dry@447.37	454.98	472.44	516.14	175,152	0.2	1,520	85	4,411	6,016
10-Oct	445.14	dry@447.37	455.04	472.56	516.00	131,764	0.0	1,523	125	4,304	5,952
11-Oct	439.55	dry@447.37	454.87	472.65	515.90	105,303	0.0	1,517	30	4,687	6,234
12-Oct	437.85	dry@447.37	455.01	472.66	515.82	86,706	3.0	1,508	0	4,507	6,015
13-Oct	438.04	dry@447.37	455.00	472.40	515.75	72,222	0.0	1,474	0	4,356	5,830
14-Oct	438.67	dry@447.37	454.85	472.41	515.69	61,081	0.0	1,464	0	4,304	5,768
15-Oct	437.63	dry@447.37	454.68	472.24	515.64	52,661	0.0	1,459	0	4,079	5,538
16-Oct	437.92	dry@447.37	454.51	472.32	515.60	46,470	0.0	1,493	0	4,057	5,550
17-Oct	437.33	dry@447.37	454.46	472.14	515.57	42,137	1.0	1,445	0	3,922	5,367
18-Oct	440.39	dry@447.37	454.40	472.22	515.54	38,062	0.0	1,425	0	3,698	5,123
19-Oct	440.73	dry@447.37	454.30	472.01	515.59	44,997	7.8	1,429	0	3,603	5,032
20-Oct	437.35	dry@447.37	453.96	472.15	515.55	39,392	0.8	1,426	0	3,445	4,871
21-Oct	437.22	dry@447.37	453.90	472.20	515.53	36,761	0.0	1,418	0	3,566	4,984
22-Oct	437.15	dry@447.37	453.84	472.46	515.50	33,021	0.0	1,428	0	3,559	4,987
23-Oct	437.20	dry@447.37	453.77	472.47	515.50	33,021	6.5	1,468	0	3,515	4,983
24-Oct	438.95	dry@447.37	454.03	471.74	515.50	33,021	0.8	1,433	0	3,478	4,911
25-Oct	438.81	dry@447.37	453.90	471.38	515.48	30,664	0.0	1,417	0	3,445	4,862
26-Oct	437.17	dry@447.37	453.78	471.89	515.45	27,329	0.0	1,393	0	3,515	4,908
27-Oct	438.32	dry@447.37	453.86	470.30	515.43	25,235	0.0	1,324	0	3,468	4,792
28-Oct	437.14	dry@447.37	453.82	470.79	515.40	22,285	3.8	1,280	0	3,475	4,755
29-Oct	436.84	dry@447.37	453.67	470.06	515.40	22,285	4.2	1,256	0	3,295	4,551
30-Oct	436.52	dry@447.37	453.56	469.97	515.42	24,227	0.0	1,275	0	3,204	4,479
31-Oct	436.14	dry@447.37	453.46	469.87	515.42	24,227	2.2	1,265	0	3,167	4,432

Monthly Equivalent Precipitation (mm) 120.6

Monthly Average Pumping (USgpm) 5,395

Notes: Flowmeter used to measure 825 Sump discharge.
Began precipitation measurements at mine site on October 1, 1991

GAYS RIVER MINE DAILY GROUNDWATER MONITORING NOVEMBER 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Hrly Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Conc. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Nov	436.77	dry@447.37	453.50	470.50	515.41	23,243	1.8	1,229		3,204	4,433
02-Nov	435.50	dry@447.37	453.74	470.59	515.45	27,329	12.5	1,203		3,168	4,371
03-Nov	436.65	dry@447.37	453.72	470.39	515.65	54,283	12.0	1,197		3,233	4,430
04-Nov	436.69	dry@447.37	453.75	470.43	515.75	72,222	2.0	1,201		3,217	4,418
05-Nov	436.83	dry@447.37	453.75	470.34	515.86	95,726	15.0	1,272		3,344	4,616
06-Nov	437.42	dry@447.37	453.79	470.36	515.93	112,859	0.3	1,239		3,290	4,529
07-Nov	438.67	dry@447.37	453.88	470.52	515.86	95,726	0.0	1,251		3,278	4,529
08-Nov	448.13	448.00	454.33	470.58	515.80	82,401	5.0	1,223		2,709	3,932
09-Nov	451.17	451.13	454.42	470.38	515.75	72,222	0.7	1,213		3,017	4,230
10-Nov	453.41	453.29	454.41	470.37	515.70	62,858	0.0	1,210		3,101	4,311
11-Nov	455.34	455.22	454.44	470.38	515.84	91,147	49.0	1,249		3,436	4,685
12-Nov	450.72	450.23	454.94	470.69	516.74	455,981	29.0	1,258		4,543	5,801
13-Nov	453.90	453.31	455.51	470.68	516.40	276,939	0.2	1,262		4,390	5,652
14-Nov	454.67	454.19	455.81	470.57	516.17	185,455	3.2	1,274		4,939	6,213
15-Nov	453.79	453.36	455.90	470.51	516.01	134,614	2.5	1,292		4,725	6,017
16-Nov	450.62	450.32	455.91	470.77	515.91	107,786	4.6	1,293		4,689	5,982
17-Nov	449.17	448.71	455.84	470.77	515.84	91,147	0.2	1,291		4,577	5,868
18-Nov	449.35	448.94	455.82	470.55	515.77	76,194	2.3	1,289		4,482	5,771
19-Nov	447.02	dry@447.37	455.74	470.56	515.72	66,508	0.2	1,304		4,601	5,905
20-Nov	445.05	dry@447.37	455.56	470.42	515.67	57,620	0.0	1,287		4,556	5,843
21-Nov	437.78	dry@447.37	455.27	470.58	515.63	51,068	0.0	1,279		4,483	5,762
22-Nov	437.64	dry@447.37	455.15	470.53	515.60	46,470	0.0	1,289		4,111	5,400
23-Nov	437.50	dry@447.37	455.06	470.62	515.57	42,137	5.0	1,284		3,976	5,260
24-Nov	437.41	dry@447.37	454.96	470.70	515.62	49,506	7.6	1,286		3,920	5,206
25-Nov	437.34	dry@447.37	454.79	470.96	515.67	57,620	7.9	1,311		3,871	5,182
26-Nov	438.44	dry@447.37	454.71	470.89	515.72	66,508	0.0	1,323		3,750	5,073
27-Nov	441.56	dry@447.37	454.80	470.80	515.69	61,081	0.2	1,320		3,667	4,987
28-Nov	441.16	dry@447.37	454.69	470.79	515.64	52,661	0.0	1,345		3,874	5,219
29-Nov	439.56	dry@447.37	454.74	470.25	515.60	46,470	0.0	1,359		4,005	5,364
30-Nov	439.18	dry@447.37	454.61	470.37	515.57	42,137	0.0	1,319		3,960	5,279

Monthly Equivalent Precipitation (mm) 161.0

Monthly Average Pumping (USgpm) 5,142

Notes: Flowmeter used to measure 825 Sump discharge.
118-844 Hole #13 Valve Throttled Back November 7, 1991, reopened fully Nov 11.

GAYS RIVER MINE DAILY GROUNDWATER MONITORING DECEMBER 1991

DATE	DW-3 (m)	ETW-1 (m)	ETW-2 (m)	ETW-3 (m)	RIVER (m)	CALCULATED RIVER FLOW (USgpm)	Precip.(mm) Mt's Air or Mine Site	825 Sump Pumping (USgpm)	Sandpit Est. Conc. (USgpm)	Weir Pumping (USgpm)	TOTAL Pumping (USgpm)
01-Dec	438.80	dry@447.37	454.67	470.53	515.54	38,062	0.0	1,340		3,990	5,330
02-Dec	438.81	dry@447.37	454.81	469.59	515.51	34,240	0.0	1,336		3,914	5,250
03-Dec	440.02	dry@447.37	454.85	469.45	515.48	30,664	0.0	1,281		3,974	5,255
04-Dec	439.95	dry@447.37	454.83	469.87	515.51	34,240	18.0	1,256		4,106	5,362
05-Dec	438.28	dry@447.37	454.71	469.71	515.71	64,667	1.3	1,262		4,155	5,417
06-Dec	438.26	dry@447.37	454.80	469.84	515.76	74,192	0.0	1,261		4,063	5,324
07-Dec							1.3	1,248		4,091	5,339
08-Dec							1.5	1,241		4,114	5,355
09-Dec	437.71	dry@447.37	454.81	470.18	515.57	42,137	0.6	1,234		4,124	5,358
10-Dec	437.70	dry@447.37	454.64	470.29	515.56	40,750	0.0	1,308		4,191	5,499
11-Dec	437.60	dry@447.37	454.46	470.12	515.57	42,137	0.0	1,259		4,056	5,315
12-Dec	437.78	dry@447.37	454.26	470.30	515.56	40,750	0.0	1,248		4,067	5,315
13-Dec	437.61	dry@447.37	454.28	470.41	515.54	38,062	0.0	1,295		4,106	5,401
14-Dec							5.0	1,287		4,132	5,419
15-Dec							16.2	1,300		4,189	5,489
16-Dec	438.72	dry@447.37	454.18	470.43	515.86	95,726	0.3	1,311		4,124	5,435
17-Dec	439.65	dry@447.37	454.67	469.45	515.75	72,222	0.0	1,284		4,149	5,433
18-Dec	440.53	dry@447.37	454.98	469.07	515.66	55,936	1.2	1,277		4,336	5,613
19-Dec	440.24	dry@447.37	454.76	468.84	515.62	49,506	7.1	1,218		4,308	5,526
20-Dec	439.11	dry@447.37	454.07	469.43	515.68	59,335	0.0	1,215		4,233	5,448
21-Dec							0.0	1,233		3,956	5,189
22-Dec							7.8	1,217		4,103	5,320
23-Dec	437.59	dry@447.37	454.07	468.31	515.62	49,506	0.7	1,188		4,105	5,293
24-Dec	437.47	dry@447.37	453.94	468.12	515.52	35,487	13.0	1,197		3,964	5,161
25-Dec							0.0	1,348		3,999	5,347
26-Dec							0.0	1,176		3,921	5,097
27-Dec	437.46	dry@447.37	454.03	469.35			0.1	1,181		3,835	5,016
28-Dec							0.2	1,180		3,842	5,022
29-Dec							0.0	1,160		3,937	5,097
30-Dec	437.46	dry@447.37	454.14	468.74	515.40	22,285	14.3	1,137		3,941	5,078
31-Dec	437.27	dry@447.37	454.11	468.11	515.41	23,243	0.3	1,133		3,773	4,906

Monthly Equivalent Precipitation (mm) 88.9

Monthly Average Pumping (USgpm) 5,300

Notes: Flowmeter used to measure 825 Sump discharge.

APPENDIX C

1991 WEEKLY DEEP WELL GROUNDWATER MONITORING DATA

GAYS RIVER MINE WEEKLY GROUNDWATER MONITORING

Hole	02-Jan-91	09-Jan-91	16-Jan-91	23-Jan-91	30-Jan-91	06-Feb-91	13-Feb-91	20-Feb-91	27-Feb-91
OW-1A	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71
OW-2	501.94	501.93	501.92	501.81	501.81	501.79	not taken	501.76	not taken
OW-3	490.86	490.77	490.78	490.22	490.78	490.71	not taken	490.94	490.91
OW-6	521.69	521.68	521.71	521.70	521.68	521.69	521.78	521.83	521.66
DW-1	477.71	477.55	477.57	477.69	477.74	477.62	477.66	477.90	478.00
DW-2	500.91	500.79	500.79	500.64	500.49	500.47	500.60	500.72	500.54
DW-3	446.21	445.68	453.81	442.90	440.86	445.42	442.82	443.16	445.21
ETW-1	449.21	dry@ 446.72	454.63	dry@ 446.72	dry@ 446.72	dry@ 446.72	dry@ 446.72	dry@ 446.72	dry@ 446.72
ETW-2	456.61	456.08	456.64	456.42	455.92	455.83	455.30	455.50	455.66
ETW-3	479.39	479.29	479.31	479.14	479.34	479.31	479.46	479.28	479.10
ETW-4	482.87	482.88	482.89	482.87	482.91	482.89	482.88	482.88	482.88
H-4	459.36	459.11	459.17	459.08	458.94	458.65	458.63	455.27	dry@ 458.29
H-5	506.49	506.11	505.83	flooded	506.04	505.99	506.04	506.22	506.29
H-7	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88
DDH 733	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	not taken
DDH 738	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00
DDH 817	445.76	444.86	444.11	492.15	480.73	481.80	not taken	not taken	not taken
Mine Water	393.00	393.00	393.00	393.00	393.00	393.00	393.00	393.00	393.00
Gays River	515.52	515.37	515.30	515.63	515.29	515.44	515.36	515.56	515.35
Avg. Pump Rate	4,286	3,805	3,073	3,277	3,463	3,356	3,331	3,259	3,320
Rainfall for Period	14.8	5.1	38.2	29.6	8.8	26.3	4.8	51.2	1.4

Groundwater levels in metres, Pumping in USgpm, Equivalent Rainfall in mm.

GAYS RIVER MINE WEEKLY GROUNDWATER MONITORING

Hole	06-Mar-91	13-Mar-91	20-Mar-91	27-Mar-91	03-Apr-91	10-Apr-91	17-Apr-91	24-Apr-91
OW-1A	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71
OW-2	501.73	501.71	501.67	501.64	501.58	501.57	501.51	501.30
OW-3	490.86	490.85	491.02	490.82	490.59	490.88	490.84	490.87
OW-6	521.82	521.84	521.86	521.85	521.78	521.80	521.79	521.82
DW-1	478.20	478.44	478.56	478.35	478.33	478.48	478.44	478.53
DW-2	500.43	500.69	500.91	500.68	500.61	500.72	500.63	500.65
DW-3	446.32	454.00	448.25	448.34	448.84	441.86	440.35	443.33
ETW-1	dry@ 446.72	455.37	450.10	449.10	449.34	dry@ 446.72	dry@ 446.72	dry@ 446.72
ETW-2	454.88	456.76	455.80	455.69	456.01	455.57	455.20	455.79
ETW-3	478.74	478.51	478.56	477.92	477.54	477.48	477.33	477.31
ETW-4	482.89	482.93	482.93	482.92	482.93	482.93	482.93	482.92
H-4	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29
H-5	not taken	506.72	506.72	506.29	506.40	506.37	506.53	Flooded
H-7	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88
DDH 733	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17
DDH 738	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00	dry@ 471.00	472.81
DDH 817	530.30	523.60	515.27	508.42	501.98	497.65	493.38	489.57
Mine Water	393.00	393.00	393.00	393.00	393.00	393.00	393.00	393.00
Gays River	516.26	515.54	515.54	515.44	515.55	515.68	515.46	515.99
Avg . Pump Rate	3,525	3,884	4,124	4,049	4,198	4,025	3,736	3,626
Rainfall for Period	67.6	22.9	20.9	13.0	30.8	12.8	5.6	63.7

Groundwater levels in metres, Pumping in USgpm, Equivalent Rainfall in mm.

GAYS RIVER MINE WEEKLY GROUNDWATER MONITORING

Hole	01-May-91	08-May-91	15-May-91	22-May-91	29-May-91	06-Jun-91	12-Jun-91	19-Jun-91	26-Jun-91
OW-1A	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71
OW-2	500.98	501.01	500.96	501.40	501.37	501.32	501.29	501.25	487.31
OW-3	490.85	490.86	490.80	490.87	490.86	490.80	490.91	490.78	490.86
OW-6	521.32	521.82	521.81	521.80	521.81	521.78	521.81	521.77	521.77
DW-1	478.42	478.41	478.45	478.47	478.46	478.37	478.44	478.19	478.15
DW-2	500.62	500.59	500.58	500.60	500.59	500.57	500.68	500.53	500.55
DW-3	454.86	458.36	459.78	460.60	462.09	461.96	456.75	440.30	439.96
ETW-1	456.17	459.47	461.40	461.40	463.59	463.21	458.10	447.32	dry@ 447.37
ETW-2	456.83	459.89	460.39	459.73	461.00	459.46	455.92	452.31	451.25
ETW-3	477.04	476.83	476.72	476.56	476.40	476.20	476.24	476.07	476.06
ETW-4	482.94	482.93	482.97	482.98	482.98	482.96	482.93	482.88	482.81
H-4	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29
H-5	505.36	506.86	506.52	506.54	506.57	506.15	506.07	505.99	505.92
H-7	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88
DDH 733	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17
DDH 738	473.18	473.06	473.01	472.83	472.99	472.84	472.92	472.90	472.91
DDH 817	485.85	482.39	479.77	477.59	475.18	472.61	471.89	469.03	467.29
Mine Water	393.00	393.00	393.00	393.00	393.00	393.00	393.00	393.00	393.00
Gays River	515.42	515.75	515.38	515.30	515.35	515.21	515.20	515.21	515.20
Avg. Pump Rate	3,845	4,390	4,463	4,511	4,576	5,008	5,437	5,359	4,250
Rainfall for Period	0.0	102.7	6.8	12.0	10.0	4.3	0.6	7.4	4.2

Groundwater levels in metres, Pumping in USgpm, Equivalent Rainfall in mm.

GAYS RIVER MINE WEEKLY GROUNDWATER MONITORING

Hole	03-Jul-91	10-Jul-91	17-Jul-91	24-Jul-91	31-Jul-91	07-Aug-91	14-Aug-91	21-Aug-91	28-Aug-91
OW-1A	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71
OW-2	486.99	486.96	486.94	486.92	486.91	486.88	486.88	486.86	486.86
OW-3	490.76	490.88	490.81	490.87	490.81	490.79	490.83	490.73	490.84
OW-6	521.76	521.77	521.61	521.75	521.71	521.70	521.72	521.71	521.26
DW-1	478.05	478.09	478.04	477.94	477.70	477.62	477.45	477.17	477.39
DW-2	500.45	500.58	500.52	500.53	500.48	500.45	500.48	500.23	500.35
DW-3	439.09	451.56	449.87	448.27	438.71	438.51	438.48	441.32	442.17
ETW-1	dry@ 447.37	451.88	450.24	448.59	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37
ETW-2	451.34	451.49	451.62	450.73	447.29	444.66	445.11	447.09	452.32
ETW-3	476.18	475.14	474.89	475.10	476.00	473.08	474.43	473.90	474.86
ETW-4	482.75	482.68	482.61	482.53	482.45	482.42	482.39	482.31	482.25
H-4	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29
H-5	505.99	506.06	505.95	506.27	506.34	506.41	506.50	506.56	506.30
H-7	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88
DDH 733	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17
DDH 738	472.86	472.96	472.94	472.87	472.83	472.56	472.85	472.74	472.89
DDH 817	465.67	464.16	462.65	461.47	460.25	459.10	458.04	457.03	455.67
Mine Water	393.00	393.00	393.00	393.00	393.00	393.00	393.00	39. 30	393.00
Gays River	515.20	515.19	515.24	515.21	515.04	515.15	515.21	515.61	515.17
Avg. Pump Rate	3,934	3,779	3,654	4,108	4,030	3,650	3,326	3,701	4,149
Rainfall for Period	2.0	0.6	19.2	6.0	38.3	23.3	30.9	72.1	1.4

Groundwater levels in metres, Pumping in USgpm, Equivalent Rainfall in mm.

GAYS RIVER MINE WEEKLY GROUNDWATER MONITORING

Hole	04-Sep-91	11-Sep-91	18-Sep-91	25-Sep-91	02-Oct-91	09-Oct-91	16-Oct-91	23-Oct-91	30-Oct-91
OW-1A	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71
OW-2	486.84	486.83	486.81	486.83	486.86	486.88	486.86	486.84	486.86
OW-3	490.88	490.94	490.79	490.88	490.83	490.74	490.77	490.77	490.79
OW-6	521.73	521.72	521.73	521.72	521.71	521.71	521.71	521.69	521.68
DW-1	477.50	477.60	477.47	477.65	477.73	478.07	478.21	478.12	478.11
DW-2	500.39	500.61	500.44	500.58	500.56	500.54	500.59	500.58	500.66
DW-3	441.71	438.72	439.97	449.03	439.72	444.37	437.92	437.20	436.52
ETW-1	dry@ 447.37	dry@ 447.37	dry@ 447.37	448.20	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37
ETW-2	453.11	452.70	452.68	453.89	454.36	454.98	454.51	453.77	453.56
ETW-3	472.77	475.88	473.69	473.97	473.52	472.44	472.32	472.47	469.97
ETW-4	482.19	482.13	482.06	482.00	481.96	481.93	481.94	481.96	481.97
H-4	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29
H-5	506.95	506.94	507.00	507.42	508.07	flooded	507.94	507.68	507.51
H-7	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88
DDH 733	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17
DDH 738	473.01	472.59	472.34	472.43	472.34	472.17	472.06	471.47	471.47
DDH 817	455.49	454.32	453.66	452.93	452.20	450.80	451.95	450.45	449.90
Mine Water	393.00	393.00	393.00	393.00	393.00	393.00	393.00	393.00	393.00
Gays River	515.22	515.14	515.31	515.81	515.82	516.14	515.60	515.50	515.42
Avg. Pump Rate	4,367	4,355	4,499	4,928	5,641	5,965	5,841	5,050	4,751
Rainfall for Period	3.6	38.7	2.5	71.8	68.0	53.5	3.0	16.1	8.8

Groundwater levels in metres, Pumping in USgpm, Equivalent Rainfall in mm.

GAYS RIVER MINE WEEKLY GROUNDWATER MONITORING

Hole	06-Nov-91	13-Nov-91	20-Nov-91	27-Nov-91	04-Dec-91	11-Dec-91	18-Dec-91	23-Dec-91	31-Dec-91
OW-1A	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71
OW-2	486.84	486.88	486.87	486.86	486.85	486.83	486.81	486.80	486.78
OW-3	490.80	490.96	490.86	490.73	491.19	490.84	490.94	490.97	490.77
OW-6	521.71	521.80	521.78	521.75	521.83	521.75	521.78	521.79	521.72
DW-1	478.08	478.37	478.25	478.24	478.72	478.42	478.55	478.56	478.29
DW-2	500.59	500.76	500.69	500.40	501.09	500.70	500.82	500.68	500.59
DW-3	437.42	453.90	445.05	441.56	439.95	437.60	440.53	437.59	437.27
ETW-1	dry@ 447.37	453.31	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37
ETW-2	453.79	455.51	455.54	454.80	454.83	454.46	454.98	454.07	454.11
ETW-3	470.36	470.68	470.42	470.80	469.87	470.12	469.07	468.31	468.11
ETW-4	482.00	482.02	482.07	482.11	482.15	482.18	482.22	482.25	482.27
H-4	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29
H-5	507.94	flooded	508.29	507.99	507.88	507.85	508.15	507.96	507.53
H-7	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88
DDH 733	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17
DDH 738	471.46	471.56	471.45	471.30	471.53	471.28	471.40	471.30	471.21
DDH 817	449.41	449.00	448.64	448.20	447.78	447.38	447.01	446.76	446.36
Mine Water	393.00	393.00	393.00	393.00	393.00	393.00	393.00	393.00	393.00
Gays River	515.93	516.40	515.67	515.69	515.51	515.57	515.66	515.62	515.41
Avg. Pump Rate	4,461	4,734	5,940	5,267	5,294	5,372	5,444	5,355	5,078
Rainfall for Period	45.8	83.9	13.0	20.5	18.0	4.7	22.7	15.6	27.9

Groundwater levels in metres, Pumping in USgpm, Equivalent Rainfall in mm.

APPENDIX D

1991 MINE DISCHARGE WATER CHEMISTRY

Sampling Date:		02-Jan-91	09-Jan-91	16-Jan-91	23-Jan-91	30-Jan-91	06-Feb-91	13-Feb-91	20-Feb-91	27-Feb-91
Aluminum	(Al)	0.29	0.85	0.55	0.29	0.66	0.53	1.72	0.08	0.13
Arsenic	(As)	< 0.005	< 0.005	0.006	< 0.005	< 0.005	< 0.005	0.005	< 0.005	< 0.005
Calcium	(Ca)	491	491	510	526	566	516	508	521	470
Copper	(Cu)	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	(Fe)	0.33	3.10	1.98	1.00	1.03	1.16	3.51	0.76	0.67
Lead	(Pb)	0.18	0.27	2.0	0.18	0.08	0.75	0.77	0.08	0.45
Magnesium	(Mg)	10.1	15.3	16.2	10.6	9.5	13.0	13.6	9.6	15.5
Mercury	(Hg)	----	< 0.05	----	----	----	----	----	< 0.0002	< 0.0002
Nickel	(Ni)	0.02	0.02	0.01	0.01	0.02	0.01	0.03	0.02	0.03
Sodium	(Na)	10.7	11.1	11.5	8.6	8.0	10.8	11.6	8.9	11.3
Zinc	(Zn)	0.31	0.48	3.37	0.16	0.12	0.70	0.62	0.16	0.42
Sulphate	(SO4)	1140	1190	1190	1290	1300	1250	1190	1240	1180
Total Organic Carbon		0.6	1.8	0.9	1.0	1.0	1.2	2.2	1.5	1.1
Chloride	(Cl)	12.0	14.0	14.0	20.0	18.0	14.0	18.0	14.0	14.0
Total Suspended Solids		108	500	251	407	198	205	640	103	384
Spec. Conduct.	umhos/cm	2960	3000	3020	3100	3190	3120	3140	3300	3220
Color	TCU	5	16	10	7	10	< 3	< 3	11	8
Turbidity	NTU	99	259	131	310	132	86.9	183	54.5	252
pH	units	7.7	7.6	7.7	7.7	7.6	7.6	7.7	7.5	7.6
Alkalinity		88	87	89	140	99	83	82	76	93
Oil and Grease		< 1	< 1	280	< 1	< 1	< 1	< 1	< 1	< 1

Values are in mg/l unless otherwise noted.

GAYS RIVER MINE

MINE DISCHARGE WATER CHEMISTRY

1991

Sampling Date:		06-Mar-91	13-Mar-91	20-Mar-91	27-Mar-91	03-Apr-91	10-Apr-91	17-Apr-91	25-Apr-91
Aluminum	(Al)	0.70	0.65	1.18	0.75	0.12	1.57	0.20	0.36
Arsenic	(As)	0.007	< 0.005	< 0.005	< 0.005	< 0.005	0.009	< 0.005	< 0.005
Calcium	(Ca)	501	509	445	480	455	450	490	472
Copper	(Cu)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	0.01
Iron	(Fe)	2.30	1.20	1.23	0.81	0.77	5.80	1.20	0.42
Lead	(Pb)	1.6	0.47	0.31	0.24	0.18	1.7	0.26	0.06
Magnesium	(Mg)	13.2	12.4	12.3	13.0	9.7	11.2	9.6	10.9
Mercury	(Hg)	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Nickel	(Ni)	0.04	0.02	0.03	0.05	0.04	0.06	0.05	< 0.01
Sodium	(Na)	9.8	9.5	9.4	10.4	8.0	8.7	8.0	9.3
Zinc	(Zn)	0.98	0.51	0.28	0.21	0.27	4.91	0.29	0.24
Sulphate	(SO_4)	1160	1150	620	2350	1140	1140	1180	1130
Total Organic Carbon		1.0	1.3	0.5	0.5	0.5	0.5	0.7	0.5
Chloride	(Cl)	13.0	13.4	13.0	13.0	10.0	11.9	12.0	13.0
Total Suspended Solids		1880	661	263	212	98	294	354	1040
Spec. Conduct.	umhos/cm	3060	2920	2910	3120	2770	3000	3060	3150
Color	TCU	4	4	5	3	< 3	4	6	17
Turbidity	NTU	776	281	62.9	147	47.8	170	146	354
pH	units	7.7	7.7	7.7	7.8	7.3	7.6	7.6	7.7
Alkalinity		79	86	78	54	72	92	77	79
Oil and Grease		1.0	1.1	< 1	< 1	< 1	< 1	< 1	< 1

Values are in mg/l unless otherwise noted.

Sampling Date:		01-May-91	08-May-91	15-May-91	22-May-91	29-May-91	05-Jun-91	12-Jun-91	19-Jun-91	26-Jun-91
Aluminum	(Al)	0.40	0.82	1.56	0.17	2.13	< 0.05	< 0.05	0.33	0.31
Arsenic	(As)	< 0.005	0.007	0.008	< 0.005	0.006	< 0.005	< 0.005	< 0.005	< 0.005
Calcium	(Ca)	475	465	447	446	477	461	491	----	522
Copper	(Cu)	< 0.01	< 0.01	0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	(Fe)	2.20	4.02	5.27	0.48	2.83	0.21	0.15	0.48	0.40
Lead	(Pb)	0.85	1.70	0.56	0.08	0.42	0.02	0.04	0.09	0.10
Magnesium	(Mg)	10.7	11.5	8.6	9.6	11.1	11.4	13.9	----	14.0
Mercury	(Hg)	< 0.00005	0.00020	< 0.00005	< 0.00005	< 0.00005	0.00010	< 0.00005	< 0.00005	< 0.00005
Nickel	(Ni)	0.05	0.07	0.06	0.02	0.04	0.01	0.02	0.02	0.02
Sodium	(Na)	8.8	8.3	8.2	7.5	9.1	8.3	9.7	----	10.4
Zinc	(Zn)	1.15	1.57	0.79	0.13	0.20	0.07	0.14	0.14	0.16
Sulphate	(SO4)	1160	1100	1120	1030	1250	1300	1250	----	1390
Total Organic Carbon		0.6	0.7	1.5	0.6	1.1	0.9	0.7	1.0	1.0
Chloride	(Cl)	11.0	11.0	10.0	8.9	10.0	9.1	12.0	----	12.7
Total Suspended Solids		380	573	492	121	1190	108	110	----	291
Spec. Conduct.	umhos/cm	2940	3000	2890	3100	3170	3100	3230	----	3320
Color	TCU	5	< 3	5	6	< 3	< 3	6	----	14
Turbidity	NTU	193	156	402	57.7	812	71.4	64.3	----	202
pH	units	7.6	7.6	7.5	7.5	7.5	7.6	7.5	----	7.5
Alkalinity		82	74	70	72	52	71	77	----	82
Oil and Grease		1.6	3.2	< 1	< 1	1.0	< 1	< 1	1.3	< 1

Values are in mg/l unless otherwise noted.

GAYS RIVER MINE

MINE DISCHARGE WATER CHEMISTRY

1991

Sampling Date:		03-Jul-91	10-Jul-91	17-Jul-91	24-Jul-91	31-Jul-91	07-Aug-91	14-Aug-91	21-Aug-91	28-Aug-91
Aluminum	(Al)	< 0.05	3.40	0.06	0.35	0.26	0.17	0.09	0.78	0.14
Arsenic	(As)	< 0.005	0.009	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Calcium	(Ca)	516	512	513	481	507	535	557	525	533
Copper	(Cu)	< 0.01	0.02	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	(Fe)	0.18	5.60	0.20	1.13	1.07	0.42	0.57	1.76	0.53
Lead	(Pb)	0.08	0.91	0.11	0.19	0.15	0.05	0.02	0.04	0.03
Magnesium	(Mg)	13.9	17.2	17.4	14.8	16.5	16.2	16.1	15.7	15.6
Mercury	(Hg)	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Nickel	(Ni)	0.0	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.02
Sodium	(Na)	10.9	12.1	12.3	13.3	12.0	12.5	12.2	11.3	11.7
Zinc	(Zn)	0.12	1.00	0.26	0.20	0.26	0.19	0.18	0.23	0.18
Sulphate	(SO4)	1220	1220	1180	1250	1240	1210	1260	1230	1220
Total Organic Carbon		0.8	1.1	1.0	1.7	0.7	1.4	0.8	1.1	1.5
Chloride	(Cl)	14.0	14.0	14.0	17.0	14.0	14.2	15.4	13.9	12.8
Total Suspended Solids		114	640	136	311	209	50	81	229	56
Spec. Conduct.	umhos/cm	3360	3270	3170	3550	3500	3500	3470	3230	3420
Color	TCU	11	9	16	5	5	< 3	< 3	7	6
Turbidity	NTU	55.9	333	65	202	129	36.6	42.0	196	32.1
pH	units	7.6	7.6	7.9	7.6	7.5	7.5	7.8	7.6	7.9
Alkalinity		85	92	100	95	93	93	98	92	98
Oil and Grease		< 1	< 1	< 1	1.3	< 1	< 1	< 1	< 1	< 1

Values are in mg/l unless otherwise noted.

Sampling Date:		04-Sep-91	11-Sep-91	18-Sep-91	25-Sep-91	02-Oct-91	09-Oct-91	16-Oct-91	23-Oct-91	30-Oct-91
Aluminum	(Al)	0.27	0.26	0.11	2.83	0.47	0.10	0.34	0.28	0.35
Arsenic	(As)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Calcium	(Ca)	545	539	527	529	487	475	515	500	515
Copper	(Cu)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	(Fe)	0.89	1.87	0.32	2.13	1.35	0.32	0.80	0.94	0.40
Lead	(Pb)	0.02	0.05	0.02	0.08	0.23	0.02	0.02	0.02	0.02
Magnesium	(Mg)	14.1	15.4	11.7	12.2	10.2	10.7	10.1	10.4	11.2
Mercury	(Hg)	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00010	0.00006	0.00005	< 0.00005
Nickel	(Ni)	0.02	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02
Sodium	(Na)	10.3	10.9	9.9	9.7	7.9	7.6	7.6	7.9	8.7
Zinc	(Zn)	0.16	0.22	0.10	0.12	0.17	0.15	0.10	0.13	0.14
Sulphate	(SO_4)	1220	1200	1240	1230	1090	1130	1180	1190	1120
Total Organic Carbon		0.9	1.1	1.0	0.8	1.1	1.6	0.8	0.8	1.7
Chloride	(Cl)	12.0	13.0	12.7	12.6	10.0	9.6	9.8	9.6	11.2
Total Suspended Solids		128	192	84	197	620	106	260	317	195
Spec. Conduct.	umhos/cm	3250	3450	2920	3040	2680	2920	2900	3170	3120
Color	TCU	< 3	6	< 3	8	8	14	12	9	3
Turbidity	NTU	61.2	93.3	41.5	77.2	348	54.9	162	188	148
pH	units	7.7	7.7	7.9	7.5	7.4	7.3	7.3	7.5	7.5
Alkalinity		93	97	92	93	89	98	98	87	97
Oil and Grease		< 3	< 3	< 3	ml	ml	ml	ml	ml	----

Values are in mg/l unless otherwise noted.

Sampling Date:		06-Nov-91	13-Nov-91	20-Nov-91	27-Nov-91	04-Dec-91	11-Dec-91	18-Dec-91	24-Dec-91	31-Dec-91
Aluminum	(Al)	0.15	0.15	0.67	0.21	0.05	0.07	0.06	0.17	0.17
Arsenic	(As)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Calcium	(Ca)	524	541	915	508	431	499	477	492	494
Copper	(Cu)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	(Fe)	0.38	0.57	1.56	0.43	0.35	0.25	0.35	0.38	0.33
Lead	(Pb)	< 0.02	0.04	0.02	< 0.02	0.02	< 0.02	< 0.02	< 0.02	< 0.02
Magnesium	(Mg)	10.8	9.3	9.9	10.1	10.1	10.9	9.2	8.8	9.3
Mercury	(Hg)	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Nickel	(Ni)	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.03	0.03
Sodium	(Na)	8.6	7.3	7.3	10.2	8.0	7.6	6.9	7.0	7.5
Zinc	(Zn)	0.11	0.17	0.14	0.10	0.14	0.10	0.08	0.08	0.10
Sulphate	(SO_4)	1230	1120	1100	1200	1120	1190	1190	1170	1190
Total Organic Carbon		1.7	1.3	1.6	1.1	1.8	1.5	1.7	0.7	0.7
Chloride	(Cl)	11.3	9.7	9.8	14.5	10.4	10.4	10.8	11.3	11.4
Total Suspended Solids		101	100	142	179	94	73	148	117	147
Spec. Conduct.	umhos/cm	3000	2960	3970	3160	2980	2880	2860	2990	1760
Color	TCU	4	4	28	12	4	5	6	6	5
Turbidity	NTU	60.0	92.4	70.8	78.1	45.9	31	84.2	54.8	60.1
pH	units	7.5	7.5	7.5	7.4	7.9	7.3	7.2	7.4	7.2
Alkalinity		80	90	88	90	80	87	78	80	78
Oil and Grease		------	------	------	------	------	------	------	------	------

Values are in mg/l unless otherwise noted.